SCIENTIFIC AMERICAN SUPPLEMENT No. 450

Scientific American Supplement, Vol. XVIII., No. 450.
Scientific American, established 1845.

NEW YORK, AUGUST 16, 1884.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

HISTORY OF THE ELECTRIC TELEGRAPH.*

THE dial telegraphs of Wheatstone, of which we have spoken, all had a clock-work movement, and the electro-magnet had no other role than that of regulating its escapement. This clock-work movement was soon done away with. The first apparatus that resulted from it was analogous to that shown in Fig. 8, page 7007, but the escapement wheel, instead of moving forward under the influence of the wheel-work, was actuated by the to and fro motion of the rod of the armature. This telegraph contained a second electro for the purpose of producing a call. In its successive motions the armature rod struck a bell.

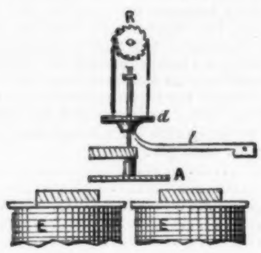


FIG. 1.—PRINCIPLE OF COOKE AND WHEATSTONE'S TELEGRAPH OF 1840.

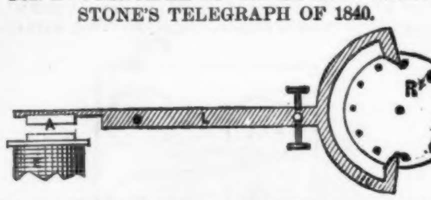


FIG. 2.—MECHANISM OF FARDELY'S RECEIVER.

Another type, that was patented in 1840 under the names of Cooke and Wheatstone, is shown in principle in Fig. 1. The armature, A, of an electro-magnet, E E, was connected with a small plate that constantly tended to raise the spring, *l*; and this plate carried two clicks that acted in opposite directions upon the wheel, R, that controlled the disk of the dial. It is easy to see that every motion of the armature of the electro-magnet caused this wheel to move forward one tooth.

Dating from this epoch several inventors occupied themselves with the dial telegraph, and the apparatus received a great many different forms.

In 1843 William Fardely constructed a dial telegraph which, in September, 1844, was put in operation upon the Taunus Railway, on the Castel-Biebrich-Wiesbaden line, and afterward upon a certain number of other German lines. The transmitter was an interrupting wheel maneuvered by a crank that revolved in front of a dial. The receiver consisted of a clock-work movement whose escapement was regulated directly by the lever, L, of the armature, A, of an electro, E (Fig. 2).

Among the dial telegraphs must be mentioned Breguet's, which was invented shortly afterward under the inspiration of Mr. Alphonse Foy, director of the administration of telegraphs, who started from the idea that the signals of the electric telegraph ought to reproduce those of the aerial telegraph. In this wise, thought he, the employes of the latter would all be prepared to maneuver the electric telegraph, and, besides, at points where a line of electric telegraph was continued by an aerial one, the latter would only have to reproduce the signals of the former.

Breguet's telegraph consisted of a double dial telegraph (Fig. 3), whose two needles, *a* and *a'*, instead of moving in front of lettered disks, revolved in front of one white plate in common. Their axes were connected by a horizontal black line, and one-half of each of them was painted black. Each needle was capable of assuming eight different positions relative to the horizontal line. It is readily seen that by causing the two needles to move simultaneously, the signals of the Chappe telegraph could be reproduced (see Fig. 3). The horizontal line and the black portions of the needles represented the arms of the aerial telegraph. The motions of the two needles were produced by two trains of clock-work, in each of which the four-toothed escapement was actuated (nearly as in the apparatus already described) by the motions of the armature of the electro-magnet. The transmitter was double, like the receiver, composed of two manipulators—one for each needle. It was therefore necessary to have two wires (in addition to the return through the earth) to operate the apparatus. Each of these manipulators (Fig. 4) consisted of a winch provided with a plug that entered one of

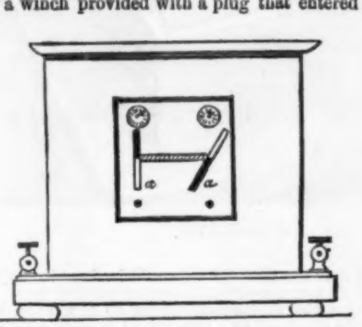


FIG. 3.—BREGUET'S TELEGRAPH.

the notches of the fixed wheel, R. The winch, in its motion, carried along a wheel, S, that was provided with a sinuosity which controlled the lever, M, and caused the spring of a second lever, M', to bear against one or the other of two terminals, A and B, between which it was capable of oscillating. When the spring bore upon the terminal to the left, a current was transmitted, and, in the opposite case, there was an interruption. In order to produce a sign, it was only necessary, then, to take a winch in each hand and turn both from left to right until they formed, with the horizontal that joined their axes, the sign to be transmitted. As the needles moved synchronously with the winches, they at once reproduced the sign.

This system is the one that was first adopted by the French administration of telegraphs. It was only necessary, later on, to modify it slightly in order to have the well known dial telegraph that is still in use in the stations of French railways.

In Paul Garnier's telegraph, invented in 1845, the receiver was a simple dial that carried the letters and was moved by a weight whose cord wound round a windlass. This dial

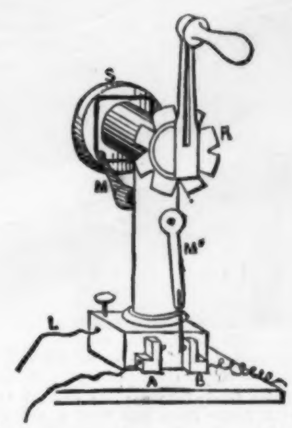


FIG. 4.—MANIPULATOR OF BREGUET'S TELEGRAPH.

was provided with fifty-four plugs that were acted upon by an escapement moved by an electro-magnet, and the signs passed, one by one, in front of the opening in a screen. The transmitter was a simple hand-lever, which, when depressed, closed the current and, through the intermedium of a click, caused a wheel that carried the same signs as the receiver to move forward one tooth. The two disks, then, moved forward synchronously, one through the action of the current, and the other through a concordant mechanical action.

In 1845, also, appeared the Ferdinand Leonhardt telegraph, which certain German authors consider the most perfect of dial apparatus. In the transmitter (Fig. 5), the needle was set in motion by a train of clock-work actuated by weights, and, every time that it passed from one letter to another, a hammer, *p'*, held by a spring, *r*, came in contact with a piece, B, and sent a current into the line. The receiver (Fig. 6) consisted of an electro-magnet, E, whose armature was raised both by a spring, *r*, and a weight, *p*, suspended from a rod, *t*. Every time the armature had been attracted, the weight lifted it, and the extremity of the rod, *t*, in falling, caused the ratchet-wheel of the needle to move forward one tooth. This telegraph was operated between Berlin and Potsdam, upon the Thuringen Railway.

Citing only by way of memorandum another dial telegraph, the invention (in 1846) of John Nott, of Cork, and employed for a certain length of time between Northampton and Blisworth, we come to Messrs. Siemens and Halske's dial telegraph, which was also invented in 1846. This apparatus notably differed from all those that preceded it, and presented the peculiarity that the same dial served at once as a transmitter and a receiver. The needles of the two stations moved at the same instant under the influence of current. The needle of the transmitter was stopped mechanically at the letter to be transmitted, and this stoppage at once brought about that of the needle of the receiver.

FIG. 5.—LEONHARDT'S TRANSMITTER.

FIG. 6.—LEONHARDT'S RECEIVER.

* By Aug. Guerout in *La Lumière Electrique*. Concluded from page 7008.

The apparatus is shown in perspective in Fig. 7. The dial was, as may be seen, horizontal. It did not consist solely of a disk that bore the signals, but it was surrounded by a series of movable keys upon which the letters were figured. It was these keys that were acted upon for causing the telegraph to operate as a transmitter. Upon depressing one of them, T (Fig. 8), a point, *p*, was depressed, which, normally, was kept raised by a spring, *e*. This point was ready, at a given moment, to arrest an arm, *f*, fixed in the very direction of the needle, *a*, upon the latter's axis, *bb*. The motion of the needle was produced by an armature, A A (Fig. 9), movable between the poles, P P, of a vertical electro-magnet. This armature carried two arms, to one of which was attached the spring, *k*, while the motions of the other, L, acted upon the wheel of the needle. The extremity of L carried a click, *h*, which, at every depression, caused the wheel to advance one tooth. The lever, L, besides, passed quite freely into a piece carried by a second lever, S. To this latter there was fixed a rod, *h'*, that carried a pawl which, when S was depressed, engaged with one of the notches between two consecutive teeth and prevented the wheel from moving forward more than one tooth. Besides this, when S rose it touched, through a piece of ivory, a screw, V'. When it fell, it made a metallic contact with the screw, V. Let us suppose, then, that the connections were made as shown in Fig. 9, that is to say, that the pile was in communication through the line, *l* (including the receiver), with the electro-magnet of the transmitter, and then with the piece, *d*, and the lever, S; and, finally, that at the moment of contact with V the current could return through a wire to the other pole of the pile. Under such conditions, the current once established, the armature, A, would be attracted, and the lever, L, in rising, would at first move slightly in the guide on S, and then, carrying along the latter, would break the contact with V. The current ceasing, L would fall again, but not without giving *h* time to seize a tooth and cause the wheel of the needle to advance that distance. The contact at V would then be established again, and a new attraction would occur, and so on. But had a key been depressed upon the transmitter, the arm of the needle would have been stopped by the point of the said key, and the lever, L, could not have placed itself in contact again. In the receiver interposed in the line, L, the spring could, on the contrary, have pulled back the lever, S, and the needle would have finished its travel toward the letter to be indicated, and then stopped. Were the key raised the needle of the transmitter would finish its travel, and the motion would continue until a new stoppage.

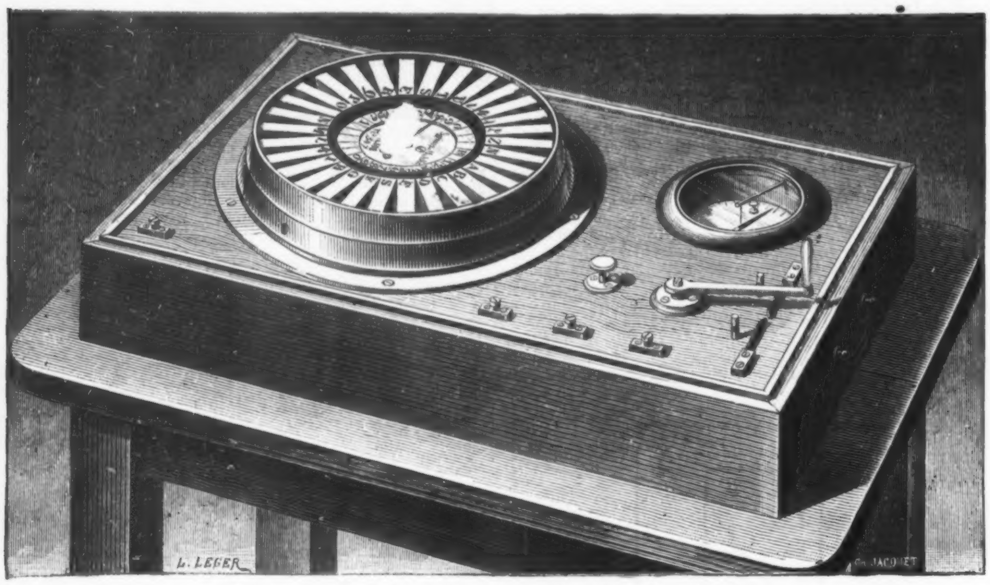
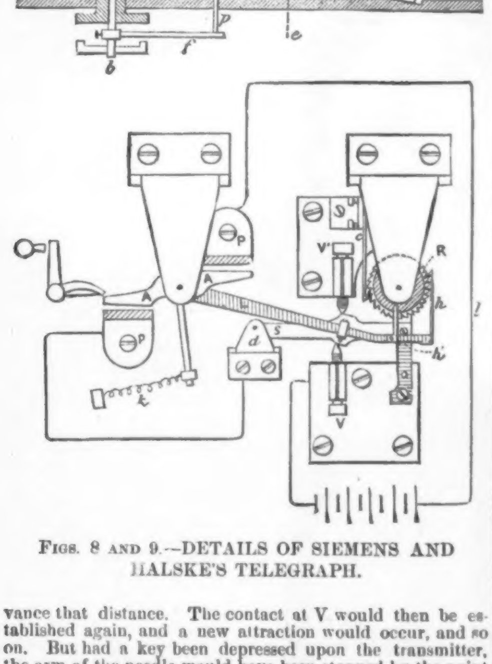


Fig. 7.—SIEMENS AND HALSKE'S DIAL TELEGRAPH.



Figs. 8 and 9.—DETAILS OF SIEMENS AND HALSKE'S TELEGRAPH.

In this apparatus, a second magnet (just like the first), whose armature carried a hammer and lever that caused interruptions, set in action a call-bell that was very similar to those now in use. Finally, the apparatus included (as shown in Fig. 7) a galvanometer for controlling the passage of the current, and a commutator designed for forming a communication with the bell or telegraph. Messrs. Siemens and Halske's apparatus soon came into extended use upon the German lines.

A telegraph that presented some analogy with the foregoing was the dial apparatus of Mr. Jacobi, to which the just-cited note of the Russian government assigns the date of 1845. In this, a needle traversed a horizontal dial (Fig. 10) under the action of clock-work controlled by an electro magnet. This needle carried along at the same time an inlaid disk which sent the current into the electro of a second apparatus. A pin was inserted into the dial at the letter that was to be transmitted. When this pin stopped the needle of the transmitter, that of the receiver likewise stopped. Fig. 10 represents the apparatus with more complication than the description would lead one to suppose that it possessed, because it relates to an apparatus provided with a printing device that Jacobi added to it a little later on. This device consisted of a type-wheel carried along by the axis of the needle and placed just beneath the dial. Another electro-magnetic device, at a given moment, applied a band of paper against the transmitted letter.

From about the same epoch of from 1845 or 1846, dates a writing telegraph that presents a certain interest in that it was one of the first ones tried in France (on the line from Paris to Rouen). We refer to the apparatus of Dujardin de Lille. Dujardin had been busying himself with telegraphy since 1838, but his telegraph was at first an electro-acoustic one in which each sign consisted of a group of blows; and then he devised, on the one hand, a writing device called by him the "electric pen," and, on the other, different forms of electric machines. Afterward, the idea occurred to him to unite one of his magneto-electric apparatus with his pen so as to make of them the transmitter and receiver of one and the same telegraph. These various apparatus were not described in the *Comptes Rendus* of the Academy until 1846; and yet Etenaud says, in his "Electric Telegraphy" (p. 41) that, at the time of the experiments made in 1845 between Paris and Rouen, an apparatus was tried that was "presented by Dr. Dujardin, and that wrote the transmitted dispatches in signs." It would be difficult, then, to say whether the apparatus that was tried was simply the electric pen set in operation by a pile, or whether it was the complete apparatus having the magneto-electric machine for transmitter. However this may be, the device that resulted from a combination of the two apparatus was as follows: The transmitter (Fig. 11) was very analogous to the machine known at present as the Breguet "*coup de poing.*" It was a horseshoe magnet, A, having each of its poles surrounded by a bobbin, B. An iron armature hinged to the poles was capable of being separated therefrom by means of a long handle. When this armature was suddenly raised, a current was produced in a certain direction, and when it was let down quickly a current in the opposite direction was produced.

This transmitter, in the first place, set in action a bell (Fig. 12) that comprised an electro, EE, between whose poles oscillated a polarized rod, AA'. In one of the directions of the current sent by the magnetic machine, the rod struck against a very sonorous glass, V, and in the other direction it pressed against a wooden sleeve, B. By causing several successive motions of the armature of the transmitter, a series of blows could be effected.

The writing apparatus (Fig. 13) consisted of a cylinder, C,

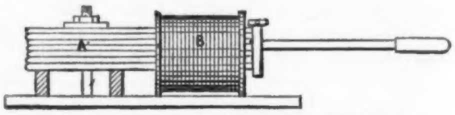


Fig. 11.—JACOBI'S TRANSMITTER.

which had a portion of its axis threaded, and which was made to revolve, as well as to move slowly forward at the same time, by means of clock-work. An electro-magnet, EE, placed horizontally beneath the cylinder, acted upon a polarized steel wire, FF', upon which was mounted a rod, A (Fig. 14), whose extremity (that was bent back vertically and surrounded by a little cloth) dipped into a cup of ink. The currents that were sent in a certain direction separated the armature and caused the inscription of a dot upon the cylinder. The succeeding and opposite current carried the armature back to the electro. Each sign was formed of two groups of dots; for example:

For *a*......................................1—2
For *b*......................................1—5
For *c*......................................2—4
For *d*......................................3—1
For *e*......................................1—1

and so on.

This apparatus had a certain amount of success with the members of the committee of representatives charged with studying the question of electric telegraphs. They were captivated with the possibility of inscribing the dispatch, but the use of a polarized armature presented inconveniences that prevented its being adopted.

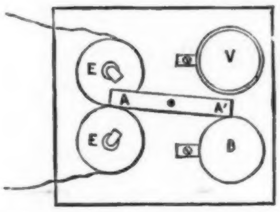


Fig. 12.—JACOBI' CALL BELL.

While electro-magnetic telegraphs were thus developing, the needle apparatus were becoming so transformed as to permit them to enter into practice. The Cooke and Wheatstone telegraph had been reduced to two needles, and even to a single one. The two-needle apparatus had been operated since 1842 at Slough; and Messrs. Gloesener and Freiherr von Weber date the invention of the single-needle telegraph back, the former to 1840 and the latter to 1841. This telegraph, however, was not patented till 1845, but it is probable that it had existed before the patent was taken out, and that the time of putting it in service was contemporaneous with that of the two-needle one.

The single-needle telegraph, one of the first forms of which is shown in Fig. 15, gave indications through the number of deflections to the right or left that the needle was made to undergo; and the manner in which the letters were written upon the dial at each side of the needle served to recall the sign corresponding to each letter. Thus, among the letters

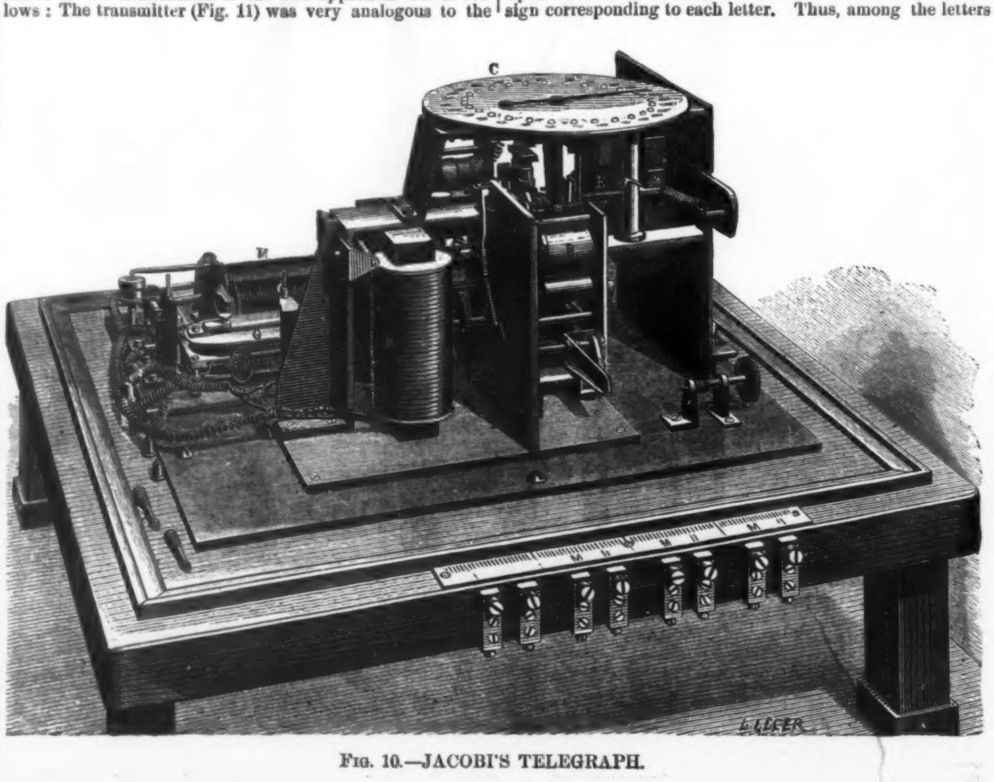
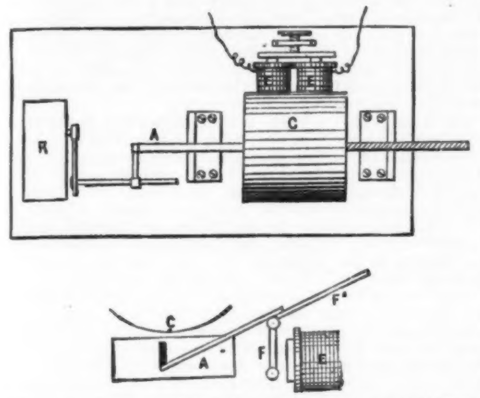


Fig. 10.—JACOBI'S TELEGRAPH.

of the first row to the left, A was represented by one deflection to the left, B by two, C by three, and D by four; for the letters of the second row, E corresponded to one deflection to the left and one to the right, F to two to the left and one to the right, and G to three to the left and one to the right; in the fourth row, J was given by one deflection to the left and three to the right, K by two to the left and three to the



FIGS. 13 AND 14.—JACOBI'S WRITING APPARATUS.

right; and, finally, in the fifth row, in order to avoid four deflections to the right, L was represented by two to the left and one to the right, and M by two to the left and two to the right. For the letters placed on the other side of the needle the signs were analogous, with the difference that a beginning was always made with deflections to the right. Thus, N was represented by one deflection to the right, R by one to the right and one to the left, U by one to the right and two to the left, W by one to the right and three to the left, Y by two to the right and one to the left, and so on.

In the type shown in Fig. 15 the currents were sent in one direction and the other by means of a manipulator (Fig. 16) which was merely a simplification of that of the five-needle telegraph.

The poles of the pile, P, were in communication with two bars, B and B', situated, one beneath and the other above two elastic keys, L and L'. One of the latter was connected with

FIG. 15.—COOKE AND WHEATSTONE'S SINGLE-NEEDLE TELEGRAPH.

the line and the other with the earth. In a state of rest, the bar, B, being in communication with L and L', grounded the line; but, if one of the keys was depressed, one of the poles of the pile was in connection with each of them, and the current sent into the line depended, in direction, upon the key that was depressed.

Later on, this manipulator was replaced by a rotating apparatus whose operation is shown in Fig. 17. It consisted of a metallic cylinder, CD, whose two halves, C and D, were insulated from each other by an ivory sleeve. This cylinder, whose axis was supported on the one hand by a bearing at I, and on the other by the frame of the apparatus, could be turned in one direction or the other by means of an external hand-lever. The parts, C and D, of the cylinder were permanently connected with the poles of the pile by means of two springs, J and E. At the two sides of the cylinder there were four additional springs, R, S, G, and H, fixed in pairs

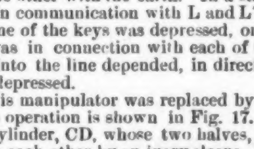
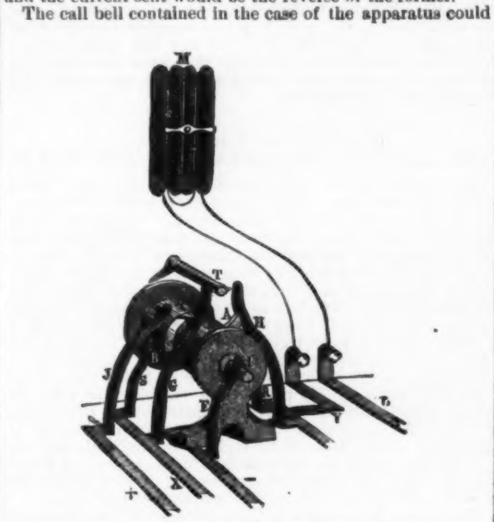


FIG. 16.

to the conductors, X and Y. The first of the latter was connected with the earth and the second with the line through the intermedium of a galvanometric helix, M. The springs, G and H, in a position of rest, bore against a piece of metal, T, that connected them and thus grounded the line and the two receivers. The other two springs, R and S, were so regulated as not to touch the cylinder, and the latter carried two metallic cams, B and A, the first of which could touch R or S, and the second could lift G or H. If, then, the cylinder were revolved from right to left, H would be raised, and the communication would be interrupted at T. At the same time, B would touch S, so that the positive pole of the pile would be connected with the ground, and the negative would be in communication with the line. If, on the contrary, the revolution were from left to right, the cams would touch G and R, the positive pole would then be grounded, and the current sent would be the reverse of the former.

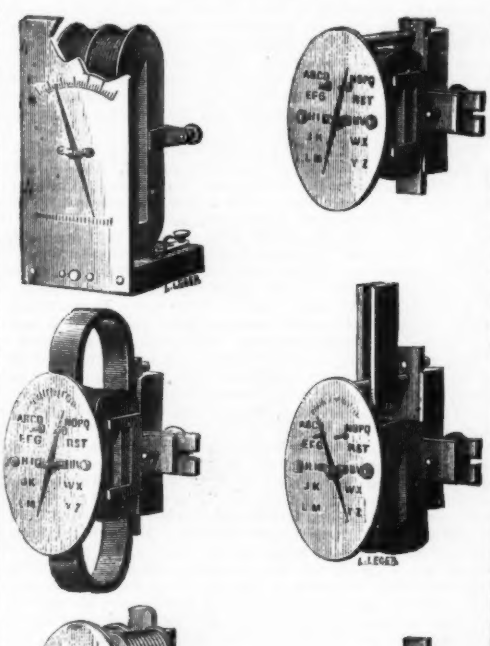
The call bell contained in the case of the apparatus could



FIGS. 16 AND 17.—COOKE & WHEATSTONE'S MANIPULATORS.

be interposed into the line by the aid of a button that may be seen at the side of the case.

Cooke and Wheatstone most usually mounted the magnetized needle of their telegraph in a galvanometric helix formed of two bobbins. A second and external needle formed the index, and the device was held in a vertical position by a counterpoise. In other arrangements they have endeavored to direct the needle by means of a magnet, or even to employ



FIGS. 18 TO 25.—DIFFERENT ARRANGEMENTS OF THE NEEDLE IN COOKE AND WHEATSTONE'S TELEGRAPH.

electro-magnets whose armature, polarized or not, was submitted to the same motions as the galvanometric needle. Finally, they have endeavored to permit of reading by sound by replacing the stops of the needles with two small flat springs, having different tones. These different arrangements are shown in Figs. 18 to 25.

The double needle telegraph (Fig. 26) was in fact only a combination of two single needle apparatus, each having its own manipulator and separate line. It utilized the motions of both hands of the employe, and, for each sign, required fewer motions of the needle. In that of the left, for example, the sign + was represented by a single motion to the left, the letter A by two, the letter B by three; E, F, and G corresponded in the same way to one, two, or three motions to the right. The same was the case with the letters placed above the needle to the right. As for those inscribed at the bottom of the tablet, they were represented by simultaneous motions of the two needles; C and D, not shown in

FIG. 26.—COOKE AND WHEATSTONE'S DOUBLE-NEEDLE TELEGRAPH.

the figure, had to be inscribed near the cross, and L and M near H and N. For these letters the corresponding deflection was immediately followed by a deflection in the opposite direction, as in the one-needle telegraph.

The manipulators were like the one shown in Fig. 18, and the call bell, which was placed in the upper part of the apparatus, was likewise interposed into the line by means of a button at the side.

The two-needle telegraph was operated from 1842 between Slough and Paddington, and contributed, even upon this line, to convince the English public of the utility of the telegraph.

"The public," says the *Electrician*, in a description of this apparatus, "considered the electric telegraph merely as a pure novelty up to the day that it served to bring to justice a man who had committed a horrible crime. The telegraph was then recognized as a communicating agent of the highest value.

"The dispatches exchanged on that occasion are engraved upon brass plates that are borne by the very instruments that were used at the time. The inscription that the Paddington apparatus bears is as follows:

"On the first of January, 1845, the following telegram was received by this instrument at the Paddington station:

"'A murder has just been committed at Salt Hill, and the supposed murderer was seen purchasing a first class ticket for London by the train that left Slough at half past seven o'clock in the evening. He was in the garb of a Quaker, with a long brown coat that reached nearly to his feet. He is in the last compartment of the second first class coach.'

"On the first of January, 1845, the following answer was sent from Paddington:

"'The train has just arrived, and a person answering in all respects to the description given by telegraph came out of the compartment named. I pointed the individual out to Police Sergeant Williams. The man entered a New Road omnibus, and Sergeant Williams got in with him.'"

Another sort of needle telegraph is that patented by Bain,

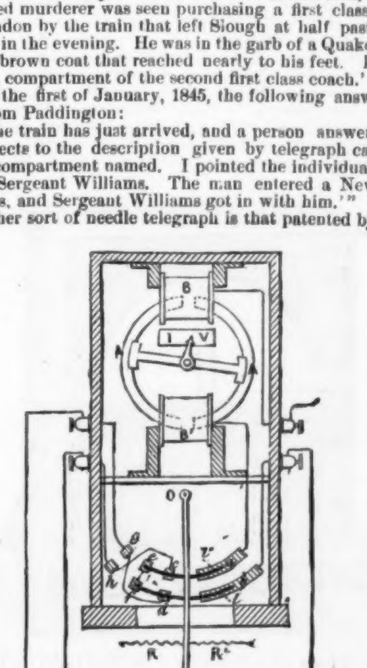


FIG. 27.—BAIN'S TELEGRAPH.

in 1843. Two curved magnets, A A^1 (Fig. 27), carried by a cross piece, passed into two bobbins, B B^1. The current, on traversing these bobbins, caused the system to deflect, and an index, according to the direction of the current, approached one of the two letters, I or V. The different groupings of these two signs furnished an alphabet in the same way that a dot and a dash served to compose Morse's. The manipulating commutator is shown at the lower part of the apparatus. It consisted of a rod, O M, that carried two springs, $l\ l^1$. These latter communicated permanently with two pieces, *a* and *b*, the first of which was connected with

the line, through the receiver, and the second with the earth. In a state of rest the springs touched two other pieces, *e* and *f*, that were connected with each other and thus connected the receiver with the earth. The current was sent in one direction or the other by means of four pieces that communicated with the pile—*e* and *h* with the positive pole, and *g* and *d* with the negative. It is easy to see that when *l* and *l'* were made to touch *g* and *h*, a current in one direction was sent into the line, and that the current was of a contrary direction when the springs touched *e* and *d*. O M was kept in its normal position by two springs, R and R'.

Bain's telegraph was operated in 1846 upon the line from Glasgow to Edinburgh. During the same year it was introduced into Germany, and there underwent several modifications. One of the last is the one that was introduced by Mr. Siemens, and in which the bobbins were replaced by an electro-magnet. Two polarized armatures, that were successively attracted or repelled by the electro, set in operation

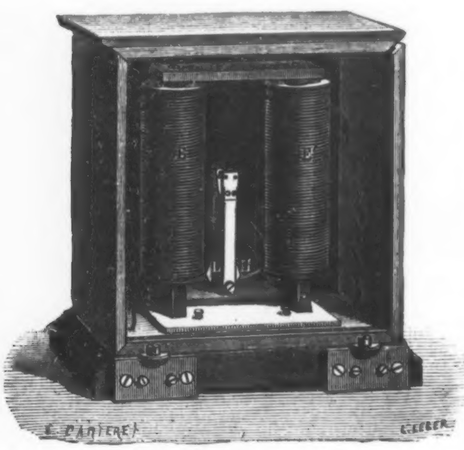


Fig. 28.

two indexes that thus indicated at will the letters I or V (Figs. 28 and 29).

If we add to all the apparatus that we have passed in review that of Vosselmann (1839), which was based upon physiological action, and in which the ten fingers, placed upon ten keys, felt feeble movements that were sent into one finger or the other by ten corresponding keys, we shall have closed the series of experiments made up to 1846.

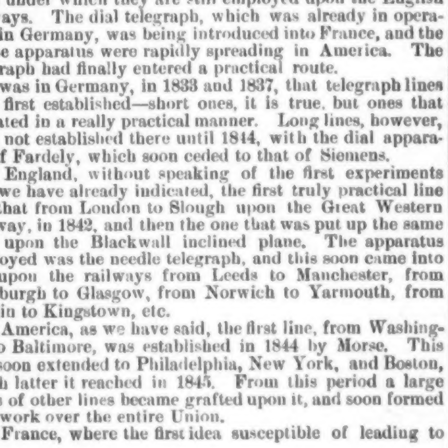
At this epoch the needle telegraphs had nearly reached the form under which they are still employed upon the English railways. The dial telegraph, which was already in operation in Germany, was being introduced into France, and the Morse apparatus were rapidly spreading in America. The telegraph had finally entered a practical route.

It was in Germany, in 1833 and 1837, that telegraph lines were first established—short ones, it is true, but ones that operated in a really practical manner. Long lines, however, were not established there until 1844, with the dial apparatus of Fardely, which soon ceded to that of Siemens.

In England, without speaking of the first experiments that we have already indicated, the first truly practical line was that from London to Slough upon the Great Western Railway, in 1842, and then the one that was put up the same year upon the Blackwall inclined plane. The apparatus employed was the needle telegraph, and this soon came into use upon the railways from Leeds to Manchester, from Edinburgh to Glasgow, from Norwich to Yarmouth, from Dublin to Kingstown, etc.

In America, as we have said, the first line, from Washington to Baltimore, was established in 1844 by Morse. This was soon extended to Philadelphia, New York, and Boston, which latter it reached in 1845. From this period a large series of other lines became grafted upon it, and soon formed a network over the entire Union.

In France, where the first idea susceptible of leading to



Figs. 28 and 29.—SIEMENS' MODIFICATION OF BAIN'S TELEGRAPH.

a realization of a practical telegraph was emitted in 1820 by Ampere, almost nothing had since been done, although Wheatstone had made his apparatus known to the Academy; and it was not till 1845 that the first experimental line was put up between Paris and Rouen, and that a communication could be had by employing an apparatus formed of an electro-magnet, between the poles of which a magnetized needle was attracted now to one side and now to the other. And, too, it was not till August 11, 1846, that the government authorized the Paris and Saint Germain Railway Co. to establish a line for its own private use. Nevertheless, a committee had been appointed and had made experiments between Paris and Rouen in 1845. The apparatus tried were those of Wheatstone, Foy-Breguet, and Dujardin. The second of these received the preference, for the reasons that we have already stated, and the construction of extensive lines was soon begun—the most important of them being that from Paris to Valenciennes through Douai and Lille.

The practical period was then reached, the apparatus already constructed contained the germs of the more improved systems that are now in use, and the preparatory period was now past. We shall therefore at this point end a study that we undertook, not in order to give a complete history of the telegraph from its origin up to our day, but solely to pass in review those historic apparatus that have permitted the electric telegraph to take its first steps, and that prepared a way for its future progress.

[Engineering and Mining Journal.]

THE CALUMET AND HECLA MINES AND PLANT.

The Extent of the Property.—The Calumet and Hecla workings, from their origin and present system of development, may be divided into three sections. Beginning from the north, where the property of the company adjoins that of the Centennial, we have the Calumet, with shafts Nos. 5, 4, 3, 2, and 1 in succession; then follows the Hecla mine, whose shafts, continuing in the same direction, follow one another in rapid succession to Nos. 1, 2, 3, and 4. Farther south, and separated from the Hecla ground proper by a stretch of about 3,000 feet of barren ground, are the Black Hills workings, opened by shafts Nos. 10, 11, and 12. In the aggregate, there is a total length of 13,350 feet on the vein, and the company possesses a sufficient area on the hanging wall side of the vein to mine to any practicable depths. We may state here that surface ownership, in Michigan, carries with it the right to the mineral, and the ground into which the pay chutes of the Calumet and Hecla dip has naturally acquired a value that carries it near the figures held for the choicest city lots in our great cities.

There has been much talk concerning the Tamarack enterprise, which is now sinking a vertical shaft in the hanging country of the Calumet and Hecla lode, to cut it in depth. It has been the habit of many not acquainted with mining in general, or the particular circumstances of the locality, to urge that the "Tamarack takes the bottom out of the Calumet and Hecla," etc. The fact is, that the nearest point of the Tamarack property to the line of the Calumet and Hecla vein is fully 3,500 feet distant from the outcrop measured on the dip of the lode. It is likely that in some respects the Tamarack enterprise will affect its powerful neighbor, but in a manner that will hardly be relished by the former. A glance at the ground still before them will teach that there is room enough for both, and those who have wealth and pluck to contemplate the sinking of a shaft fully 2,500 feet deep, on the faith of the continuity in depth of the rich deposit in the Calumet and Hecla, certainly deserve every wish for success, which, even if as brilliant as they might hope, would not in any way dim the luster of their powerful rival. The Tamarack shaft, when through, will make a fine pumping station for the drainage of the entire lode.

The rich ground of the Calumet and Hecla is distributed in chutes, of which two are distinctly defined, the one, the main chute, between the Hecla shaft No. 4 and the Calumet shaft No. 3, and the other in the South End ground. The main chute does not take a direction parallel with the dip, but makes toward the north, at an angle to it of about 70 degrees, and shows a slight tendency to widen in depth. Calumet shaft No. 5, the latest addition to the openings at this end of the line, is just beginning to enter the chute, at a depth, on the vein, of about 3,000 feet. Between the Hecla No. 4 and the South or Black Hills ground is a barren stretch of about 3,000 feet. Then the lode appears to widen, rarely going below 12 feet and reaching upward of 20 feet, and for fully 1,000 feet to near the boundary line gives promise of a productiveness rivaling the more developed parts of the territory. This chute, too, shows a northward dip.

It is hardly possible to realize the enormous resources of this long stretch of productive ground. The principal work of extraction is now going on between the 15th and 23d levels, while there are blocked out in the Calumet and Hecla mines twelve additional levels having a back each of 93 feet on the lode that have not been touched. In the Black Hills ground there are nine levels, 99 feet apart on the lode, from which not a single ton of ore has been stoped. The rock extracted from the openings has paid the entire cost of sinking drifting, machinery, track, and equipments, so that the reserves in that mine, which would be famous the world over were it not for the wonders of its neighbor, are a resource of the company for the dim future that has not cost it anything.

To sit down in cold blood to compute the ore in sight in these mines, would be as unsatisfactory a proceeding as it would be tedious. A rough estimate, based on the most conservative data, makes the total reserves equal to twenty years' work at the present rate of production of 20,000 tons of ingot per annum. For years, the development-work has not only kept pace with the work of extraction, but has gained on it. The policy that has dictated the course thus persistently followed out is one the advantages of which a trip through the mine fully explains. It makes the work of development entirely independent of that of extraction. The mine being so dry in the lower levels that water must actually be taken down into them for the use of the drillers, and the levels standing for years without a stick of timber in them, there is practically no cost for maintenance, while, on the other hand, the great advantage of non-interference with the work of extraction is secured, an advantage that more than repays the interest on an investment for development-work that is trifling when it is taken into account that the rock extracted probably more than pays for the direct outlay. A leading thought in laying out the whole plant and equipment of the mine has been to secure a steady output or uninterrupted production. This has led to a duplication of machinery throughout.

With a mill crushing more than 1,400 tons of rock a day, and being equipped to increase to 2,200 tons, it is impracticable to provide storage capacity for rock to guard against stoppages of any one part of the vast and intricate equipment. Perhaps the only place where rock could be stored in any quantity would be in the chutes in the mine, and even that is limited by the requirements of the timber-men. When once it has moved in its way out of ground, it must travel on until it is delivered into the stamps without lingering at any point or creating a clogging of the wheels that would be enormously expensive. It goes to the top of the shaft, is dumped into cars, is carried to the rock-house, goes through the rock-breakers, is loaded into cars, and is conveyed by a locomotive to the stamp mill. At the rock-houses there is, of course, storage capacity for two or three days, and probably enough is provided for at the mill to cover the same period; but the leading thought, as we have already pointed out, is steadiness and magnitude of production combined. This, of course, has involved a heavy expenditure for plant and many years of preparation during a period when the production was steadily increasing and the mine was steadily returning a heavy profit to its owners. Practically, the work is now done, and the mine, at the end of 1884, will be fully equipped to bring to the surface daily 2,500 tons of rock from a depth of 4,500 feet on the vein. With such an equipment, with a mine, as we shall see farther on, opened out far in advance of a number of years, all paid for out of earnings; with a rock carrying copper enough to bring the cost of its treatment far below any possible decline, it will be readily conceded, by even the most skeptical, that the Calumet and Hecla Company has before it a long career of prosperity.

The Vein.—The vein which the Calumet and Hecla Mining Company is working dips on an average from 38½ to 39 degrees, showing only comparatively slight variations. Its strike, too, is remarkably uniformly north 35 degrees east, and its thickness, considering the large amount of ground opened, fluctuates but little. It has been known to pinch to 3 feet and to widen out beyond 20 feet, but usually ranges from 8 to 14 feet. Thus far, no indications of any law in the distribution of the copper in the vein have been noticed. South of No. 4 shaft, Hecla, a fault crosses the vein, and a second one has been noticed farther south. They dip toward one another, so that the barren ground may prove to be simply a wedge. Neither of them threw the vein considerably; but they do appear to affect its metalliferous contents, the ground between the two faults apparently forming the limits of the barren ground between the Hecla and the South End territory. The fault near the Hecla shaft, we may here mention, is traceable on the surface by a slight ridge. The conglomerate that forms the vein varies from a fine grain to a very coarse aggregation, but no relation between the character of the conglomerate and the richness of the vein has yet been traced. Often the copper appears to have entirely displaced some constituent of this conglomerate, and massive round bowlders of solid copper, sometimes a foot in diameter and fairly uniform in size, are found. We have seen drifts where these bowlders were so frequent that the drillers were forced to abandon a number of holes. But usually the constituents of the conglomerate are practically barren, and the copper appears to have mainly displaced its cementing material. Neither in the fine grained nor in the coarse conglomerate does the copper show a defined tendency to accumulate at the hanging or foot walls. It is sometimes found near the one, sometimes near the other, and sometimes quite uniformly distributed over the whole vein, and occasionally sheets of copper appear to work in to the hanging wall. There are, of course, richer and poorer streaks of ground; but the "run of the mine," if we may so term it, the entire amount of rock extracted by removing the whole width of the vein, is very uniform from month to month and from year to year. It has been noticed in a general way that the rock seems to grow richer in depth, and we have seen in several points in the lowest levels some of the finest faces of ore in the mine.

The general average width of the stopes may be put down at a minimum of 8 feet, though in the Calumet ground through which we went it is apparently nearer 12 feet. In the Black Hills or South End mine, the vein is wider, averaging nearer 14 feet. The average yield of the Calumet and Hecla rock is fully 4·5 per cent. of ingot copper, while that of the South End is about 3·5 per cent. of ingot. In the latter territory, however, the increased width fully compensates for lower grade, the product of a running foot of the stopes yielding a larger quantity of metal.

Other Veins.—Some time since, a cross cut was driven into the foot wall country from a point on the ninth level, north of No. 4 Hecla shaft, its total length being 2,525 feet. At 138 feet, it struck a 19 foot amygdaloid vein; at 458 feet, a 10·5 foot amygdaloid; at 529 feet, a 43·7 foot amygdaloid; at 730 feet the Osceola amygdaloid, 48·6 feet thick; at 947 feet, a 20 foot amygdaloid bed; at 1,065 feet, a 6 inch calc-spar vein; at 1,156 feet, a 10 foot amygdaloid; at 1,490 feet, an 18 foot amygdaloid, and a 63 foot conglomerate, the Kearsarge vein; at 1,906 feet, a 23-foot amygdaloid bed; and at 2,062 and 2,140 feet, respectively, a 25 and a 30 foot amygdaloid bed. Of all these, the Osceola amygdaloid alone seemed promising when cut.

Mining.—All the workings are in the vein, the shafts being sunk in it. The mine is opened out by drifts 60 feet apart vertically, or 93 feet apart on the dip, in the Calumet and in the Hecla mines; while in the South End mine, the drifts are driven at distances of 65 feet vertically, or about 99 feet on the dip.

All the drifts in the mine are driven 7 by 7 feet, with power drills, by contract, each drilling gang of four men being paid from $11.50 to $15 per running foot, and being charged with wear of steel, candles, Hercules powder, and supplies. The advance per month of course varies considerably, averaging from 35 to 55 feet, attaining, however, as much as 93 feet in one case in a drift into the hanging country. There are in use in the mines, on an average, 75 Rand drills, the total equipment being about 100 drills. The system of repairs is an admirable one, being done in the machine shops of the company, where duplicate parts are always on hand. Before erecting the repaired drill underground, it is tested on the surface. Experience, we may add, has shown that for the rods high carbon steel is best. The drifts are throughout equipped of late with steel rails of a comparatively heavy section for a mine road, and the rock is taken to the nearest shaft on tilting cars with open ends, by trammers, who are furnished supplies. The proximity of shafts to one another makes the average haul a comparatively short one. Sinking is similarly done under contract, two drills generally working together. The price paid ranges from $32 to $36 a foot, the advance being from 28 to 35 feet a month. The rock is in many cases hoisted to the level above by means of a bucket and a winch, driven by compressed air.

These winches have a 7 inch cylinder and 7 inch stroke, and are built at the machine shops of the company. Whenever practicable, they are placed between the shaft and the winze nearest it, and are thus made to serve both at the same time. The stoping is done by power, using the winze as the starting point and working both ways from it to the shaft, leaving a pillar near the latter, which varies from 10 to 14 feet, and allowing a pillar under the level above of from 6 to 10 feet, according to the character of the roof and the importance of the level as a conveyer of water. Each single lift of the stopes is driven to the boundary of the section, and is followed with the most scrupulous care with timbering that for its massiveness is almost unparalleled in mining. Every foot of rock of the vein is removed, its thickness varying in the stopes of the Calumet mine—every one of which in active operation we visited—from 8 to 18 feet. In most of the stopes, the hanging wall is weak, though to the eye of a

visitor it seems to stand very firmly. Those in charge of the mine, however, appear to live up better than any underground captains whose work we have watched to the first rule in timbering, that the time when supports must be put in is before any movement of the roof can take place. The system followed is in a general way to timber up sections of from six to eight sets length on the strike alternating with free chutes or "mills," through which the rock is thrown to the level below.

The timbers, which are from 2½ to 3 feet in diameter on an average, are placed side by side, prop by prop, in many places, and are often in heavy ground, provided with from 12 to 14 feet heavy caps or "wall plates." In some lacalities, alternate sets are made up of a sill, a series of short props resting upon it, followed by an intermediate sill upon which rests a second line of props abutting against a wall plate. At some points, the props are not placed in lines immediately following one another on the dip, but alternate with heavy timbers or sills laid one above the other. Altogether, the timbering in the stopes is unparalleled for its strength, and the facts that the large vein is removed without leading to the admixture with the ore of anything but a trifling amount of hanging rock, that the old stopes seem to stand for many years without caving, and that accidents by reason of falls of the roof are almost unknown, are proof that the system thoroughly and successfully deals with the problem. How enormous the pressure is when once a movement, however slight, has set in, was strikingly illustrated in one level when the timbering was being strengthened. At the point in question, a few three-foot props were showing signs of weakness, and one about twelve feet long was beginning to exhibit the destruction of its fibers in the middle of its length by their assuming the form of an S for about an inch. The cost of timbering is, therefore, one of the heaviest items in the expenditure of the mine, being not less than ten per cent. of the entire mining cost. It practically monopolizes the hoisting shafts of the mine during the day, and requires a large force which works in gangs under a timber man. The rock accumulating in the mills is loaded on cars and trammed to the shafts, where it is dumped into skips of very heavy design, weighing about two tons and having a capacity of from 3,600 to 3,800 pounds. A good deal of the rock comes down in very heavy masses, and special gangs of men are kept busy traveling through the mine and blasting them, either by laying a cartridge on them and tamping with a little clay or by drilling holes of suitable depth and firing. Quite frequently, the drilling work in levels, shafts, and stopes is seriously impaired by striking nodules of solid copper, which entail the abandonment of the hole.

The system of contracting for stoping is peculiar. The men are paid for the fathom of 216 cubic feet, from $11 to $13; but in many cases, the full width of the vein is not counted. Thus, in a 14 foot vein, only 12 feet thickness may be counted, sometimes only 11 feet, according to the character of the rock, the manner in which it comes down, etc. A fathom of 216 cubic feet furnishes from 18 to 19 tons of rock. All the shots in the mine are fired by special gangs of blasters.

The Shafts.—Beginning at the north end, we have Calumet shaft No. 5, which has nearly reached the 30th level, where it is just about entering more kindly rock, and it promises to reach the Calumet chute at an early date. It is a wide shaft, 17 feet by 8 feet, and is equipped with two tracks for hoisting, and will in time become one of the principal shafts on the lode. At a distance of 1,115 feet south of it is No. 4 shaft, opened out to the 32d level, in dimensions of 12 by 8. It is equipped for hoisting with one of the new drums. Distant from it 445 feet is No. 3, opened down to the 32d level and now sinking to the 33d, being a hoisting-shaft through which the rock is lifted with the great speed incident to the introduction of the new Leavitt drums. It also is 12 by 8 feet. The distance from Calumet shaft No. 3 to No. 2 is 400 feet. Besides being used for hoisting, it is used principally as a pumping shaft, there being seven force pumps, all having a 9 foot stroke, while the diameter of the plunger increases from 7 inches, at the lowest, the 25th level pump, to 12 inches for the pumps on the 22d, 18th, 14th, 10th, and 6th levels, and to 14 inches for the 3d level force pump. The mine makes most of its water between the 14th and 18th levels. It was practically dry at all the lower points visited by us in the beginning of June. The pump is run at about from 5 to 7 strokes a minute, and has been able to handle all the water, even in the spring. A neat arrangement is provided for moving the valve chamber cover, which is lifted by screws until it can be hung in trunnions and run out of the way on an overhead track. Between the shafts 3 and 2 is the man-engine shaft, which passes directly through the stopes, being secured by very heavy timbering. Practically the man-engine shaft fulfills the functions of the usual winze between two shafts, being the starting point of the stopes for the ground between the 3d and 2d shafts. The man-engine rods are 12 by 12 inch timber, 28¼ inches apart from center to center. At intervals of 300 feet, more or less, their weight is carried by a 2 foot sheave over which a link chain passes. The lift is 10 feet, and the average speed is 6 strokes a minute. At intervals, the rods are fitted with small wheels running on a track of suitable length. The man-engine works smoothly and well, and admits of the ascent and descent simultaneously of a shift. No. 1 Calumet shaft is 415 feet from No. 2, and has reached the 32d level. It is still hoisting with the small drums. The distance between the Calumet No. 1 and the Hecla No. 1 shaft is 610 feet, the shaft having gone to the depth of the 32d level. Between these two shafts is the Hecla man-engine shaft. No. 1 is followed at a distance of 370 feet by No. 2 Hecla shaft, both being equipped for hoisting, to which service Nos. 3 and 4 are also devoted, following one another at a distance of 650 and 405 feet respectively. No. 3 shaft has been sunk to the 25th level, while No. 4 is down to the 9th. Until the recent purchase of the Frue 40 and 80 tracts, these shafts had reached the boundary of the Calumet and Hecla property; but now, of course, they are open to development. In the stretch between the No. 4 and No. 10 Hecla shafts, 3,350 feet in all, there are two shallow shafts of minor importance. There are two faults, one near the former shaft, and the other not far from the latter, which seem to have cut off the ore, the ground between them being practically barren. No. 10 shaft is the first of the South End or the Black Hills territory, were practically a new mine is developing. It is connected on the 5th level by a long drift, recently put through. The South End has three shafts—No. 10, down to the 3d level; No. 11, 800 feet distant from No. 10, is sunk to the 9th level; and No. 12, 480 feet from No. 11, developed to the 8th level; each level being 65 feet vertical lift. Sinking and uprising from different levels is now going on to carry No. 10 to greater depth. Measured on the 5th level, the distance from the shaft to the south boundary is 400 feet, while the north boundary is 3,700 feet from No. 5 Calumet shaft. Roughly, therefore, the company possesses 13,335 feet in the vein, and as it happens embraces all the known rich part of this conglomerate belt, since efforts to work it in the Osceola territory to the south and in the old Schoolcraft, now Centennial, territory in the north have proved failures.

The Surface Plant.—Using the shafts as the points of division in this long stretch of ground, the surface plant may be grouped as follows, beginning again at the north end. Calumet shaft No. 5 has an independent engine, and is equipped with a Guibal fan, 30 feet in diameter. We may mention here, that it is run only a few days in the year, the ventilation in all parts of the mine being excellent. Between No. 5 and No. 4 Calumet is the Calumet rock house, into which all the rock hoisted from Nos. 2, 3, 4, and 5 shafts is conveyed by means of a trestle work and an endless rope, the drum house being located between No. 4 and No. 3 shafts. Between No. 3 and No. 2 is the main Calumet hoisting and compressor engine-house, of which we shall speak in detail farther on. The gear-house is between Calumet No. 2 and No. 1 shafts, from which the Calumet and the Hecla man-engines and pumps are driven. Between Calumet shaft No. 1 and Hecla shaft No 1 is the Hecla man-engine house. The main machine shop of both mines, and the locomotive-house, are located between Hecla shafts Nos. 2 and 3, and near it is the Hecla rock house. Between shafts No. 3 and 4 is the Hecla main engine house, in which the hoisting and compressor plant are located, driven by the "Frontenac" engine. For the South End, an independent hoisting-engine is placed between No. 10 and No. 11 shafts. It will be noted, therefore, that the entire plant is duplicated, making both the Calumet and the Hecla mines fully and independently equipped each with a hoisting plant, a pumping engine, and a man-engine.

The main Calumet engine house has its chief motor, the "Superior," which was started after our visit, and ran for a couple of weeks very satisfactorily. It was stopped for some slight modifications in the air pump valves, and will probably be running by the time that these lines reach our readers. It is a compound beam engine of the Leavitt type, with 70 inch low pressure cylinder, 40 inch high pressure steam cylinder, with 6 foot stroke and Leavitt superheater. Running at a speed of 56 revolutions and with a steam pressure of 135 pounds, it develops an economical horse power of 2,500, while its ultimate capacity is 4,700 horse power, when running at 60 revolutions a minute. The engine has two 45 ton fly wheels 32 feet in diameter. Coupled to the main shaft of the engine, which is 18 maximum and 14 minimum inches in diameter and in all 130 feet long, are two pairs of Rand compressors with 36 and 32 inch cylinders and 5 and 4 foot stroke, and four hoisting drums, two of older type, 10 feet in diameter, 12 foot face, coiling 3,000 feet of rope and driven by V friction clutch gearing, and two 20 foot Leavitt drums, engaging by means of an Osgood & Blessing hydraulic clutch. They carry 4,000 feet of inch and a quarter rope, and hoist at a speed of 1,080 feet a minute. The hydraulic clutch is so thoroughly under the control of the engineer that it lifts the load gently and without shock, and that the full speed is attained after the skip has been hoisted a few feet without causing the heavy jars that are so destructive to hoisting ropes. We have watched the work of the drum as evidenced by the movement of the skip underground, and are convinced that the hydraulic clutch is far superior to the ordinary contrivances in use at mines. At present, two of the old drums have been removed, and two new ones are to be put in in their place, all this work being done while the old drums are running at one side and the pair of new ones on the other side. The plant will finally consist of six Leavitt drums, each capable of carrying 4,000 feet of rope. The drums are grooved, not in sections, as heretofore, but as a whole mounted on their shafts. They weigh 60 tons each. The "Superior" will also drive by wire rope transmission, over 15 foot sheaves, the machinery in the gear house, to which we shall refer presently. In this main engine house there are two reserve engines, one driving the compressors, a Corliss, with 30 by 48 cylinder, running 50 revolutions a minute, and the second, at the other end, driving the drums, which is a horizontal Leavitt engine, 40 by 60 inch cylinder, running at a speed of 50 revolutions. This engine house, we are convinced, has no rival for its size in this country, in the magnitude and beauty of its machinery and the enormous work it is called upon to perform. Considerable trouble has been experienced here, as well as at other points, in the surface plant of the mine, with a material for the foundations that proved very unsatisfactory after being in the use for some time. It is a sandstone, quarried near the railroad leading to the mill, which, when tested, showed itself capable of resisting a crushing strain of 5,500 pounds per square inch. After remaining in the foundation for some time, however, it begins to exhibit a shrinkage nearly equal to that of pine wood, and a number of cracks appear in the stone. This has made it necessary to take out the foundation in many cases, and to replace it with concrete and a capping of Cape Ann granite. With these changes, and with the very heavy bed plates used throughout in all the machinery, the plant possesses a solidity more than equal to any tax upon its permanency. Steam is furnished to the engines in the Calumet engine house by three boilers designed by Mr. Leavitt, and built by Messrs. Kendall & Roberts, of Cambridgeport, Mass. They are covered with a mixture of sawdust and plaster of Paris, which has proved to be an excellent and cheap non-conductor. Near the boiler house is a large coal shed.

Between Calumet shafts Nos. 2 and 1 is the gear house, containing the machinery for driving the two man engines and pumps. At present, it is run by a Porter-Allen engine, with 18 inch cylinder and 3 foot stroke, running at a speed of 192 revolutions. In the future, this engine will be merely a reserve, the machinery to be driven from the "Superior" by wire rope transmission. The sheave at the gear house is 15 feet in diameter, and will make 133⅓ revolutions a minute. A clutch is provided on the sheave shaft to throw it in and out of gear. From the main Porter-Allen engine shaft, provided with a clutch, the power is transmitted by a belt to a second main shaft, from which, by cog gearing, it is transmitted to the four shafts to which the cranks of the two man engines and pumps are attached. By heavy connecting rods, the motion is transmitted to rockers, the two Hecla rockers being mounted on hollow shafts 32 inches in diameter and 40 feet long, made of gun iron, in order to carry them into line with the shafts. From the rockers, wooden rods transmit the power to the bobs at the shafts, to which the pump and man engine rods are connected. Every one of the four main shafts is provided with Robertson clutches to throw it in and out of gear. The entire plant is of an exceedingly massive and substantial character, gun iron castings being the material used for the bobs.

The Hecla engine-house, containing the machinery for the Hecla mine principally, is, like the others, a fine brick structure, and roomier than the Calumet building. The main engine, recently completed, is the "Frontenac," a Leavitt compound engine of the latest type, embodying all the modifications of detail suggested by the experience with the others. The "Frontenac" has a 27¾-inch high-pressure cylinder, a 48-inch low-pressure cylinder, a 6-foot stroke and a 25-foot fly-wheel weighing 61,300 pounds. It was started early in June, and, driven for the first time, accomplished the feat of running without a load at uniform speed of 60 revolutions a minute, with a steam pressure of 110 pounds, and throttle wide open. The engine drives the four hoisting-drums of the Hecla end, each 24 feet in diameter and coiling 3,000 feet of rope. These drums are of more recent pattern than those being displaced by the Leavitt drums at the Calumet end, but still do not, in elegance of design and efficiency, compare with the latter. They are driven by V friction-gearing, the shaft being bodily lifted until it engages. Until quite recently, these drums were driven by a 30 by 72-inch Corliss engine, which will now be held as a reserve. The Hecla mine has one a pair of 28 by 48-inch Rand air-compressors, until recently driven by a Corliss engine, but now to be run by the "Frontenac." We understand that they will be displaced by larger compressors of the same make. The "Frontenac" will also drive the machinery in the small but very well-appointed machine and repair shop close by, in which all the current repairs in machinery and in the rock-drills are made.

The rock as hoisted from the mine is taken automatically, by an endless hemp rope, driven by a small engine, on a trestle-track, which overcomes any difficulties due to heavy snow-falls, to the rock-house of the Calumet and to that of the Hecla. At these rock-houses, the rock is reduced by rock-breakers to a size not exceeding that of a fist. The largest pieces are broken by a Hodge & Christie hammer, and are then put through a very large rock-breaker. The run of the mine is passed through rock-breakers of ordinary size, of which there are seven at the Calumet rock-house and five at the Hecla rock-house. The South End mine is not yet equipped in this manner, the rock being dumped until wanted, and thus at the present time acting as a reserve. The Calumet rock-house machinery is driven by a small horizontal engine, the rock being delivered into chutes from which it drops into the railroad cars. At the Hecla rock-house, the bins are of greater capacity, and are capable of storing fully two days' supply. The rock-house machinery will, in the future, be driven by the Superior and the Frontenac respectively. Now, nearly all the run of the mine, a good deal of the fine, and all the course, is put through the crushers, which could be more steadily supplied with material requiring actual work, if the rock as it comes from the mine were dumped on a grizzly screen. It is likely that at no distant date this part of the plant will undergo the remodeling that it needs.

The entire surface plant is supplied with water by the water-works, situate at a pond in the hanging country of the lode at some distance from it. The water-works are equipped with a splendid small Leavitt compound pumping-engine, having an 11¾-inch high-pressure, and a 24-inch low-pressure cylinder, 4-foot stroke and 17-inch plungers, with a capacity, running at 37 revolutions, of 5 million gallons. As a reserve, there is a Worthington pumping-engine, with 14 and 24-inch cylinders, 3-foot stroke, and 20-inch plungers. The water is furnished through a 16-inch main to a stand-pipe, 80 feet high, located near the Calumet engine-house. The mine-pumps deliver into the pond, and no trouble from scarcity of water has been experienced even in the driest seasons or in winter.

It will be seen, therefore, from this hasty sketch, that the surface plant is on a magnificent scale, and is so arranged that its equipment is for two mines independently, and that throughout there are engines in reserve fully capable of carrying on the work at an hour's notice. One point that might possibly strike unfavorably those mining engineers conversant with the handling of enormous quantities of material in European and American collieries is, that the rock is hoisted in skips, by single ropes, without taking advantage of the weight of an empty descending skip, to counterbalance that of the one ascending. This might be particularly objected to because the dead-weight of the skip seems disproportionately great as compared with the load carried. The leading cause for this apparent neglect of an important source of economy is, we take it, the fact that the dimensions of the old slopes are too small to admit of double track. That this is the case, is indicated by the fact that the latest shaft sunk, No. 5, is considerably larger than the others, and is equipped with a double track.

Another point that might lead to a diversity of opinion is the general plan of concentrating the machinery plant, while scattering the work of hoisting over a long line through a number of slopes, thus necessitating the use of long lines of wire rope above ground. It might be urged that it would be better to concentrate the hoisting in one or two main slopes or shafts, with cages, casting off the skips, and using rolling stock that is filled at the "mill" underground, and is dumped at the rock-house in the immediate vicinity of the main shaft. The advantages would be a reduction in the dead-weight and a saving in the cost of maintenance of ropes. Aside from the fact that this would involve a greater expense for underground tramming, and that the great number of levels from which hoisting goes on would make the constant changes troublesome, there is one great leading fact that operates against the centralization plan, and its principal advantage is the saving of the cost of maintenance of a number of shafts instead of one. That fact is, that in the Calumet and Hecla mines enormous quantities of timber must go into the mine. We have therefore two currents of transportation, if we may so term it, one of rock out of the mines and one in an opposite direction into the slopes, which are in danger of constantly conflicting with one another. First of all, it would not be good practice to haul sticks of timber three or four feet in diameter and from 10 to 20 feet long, for any distance, when it can be done cheaper on the surface than underground. Therefore a number of shafts in close proximity to one another becomes an economy instead of a waste. Then hoisting rock must be practically suspended while the timber is going in, and although the weight of the latter is not nearly equal to that of the former, its unwieldy character calls for so much time in handling that it occupies nearly all the shafts during the day, while the night is devoted to hoisting. Nor would it be possible to use a number of slopes simply for lowering timber while one shaft was steadily employed on rock, because transportation of the levels would be seriously interfered with by the improvement of timber. The system employed is therefore peculiarly adapted to local circumstances, and the employment of large engines is rendered more economical still by the fact that they have a steady, uniform minimum load in driving the air compressors and other machinery.

The Stamp-Mill.—The mine is connected with the mill by

a railroad equipped with five twenty-ton locomotives, kept in repair at the machine-shops of the company. The cars, with drop-bottom, carry an average load of 4·2 tons, and are made up into trains averaging 40 cars, a train leaving the mines every hour, approximately. The grade is a heavy one, making a maximum of about 190 feet down to the mill, and has a number of pretty sharp curves. It reaches the head of an incline at a distance of about four miles. At the incline, the cars are uncoupled in series of five, and are drawn to the incline by an auxiliary stationary engine. The rope runs over a sheave, the full cars carrying the empties up, together with any cars loaded with timber, coal, or machinery that may be shipped to the mine, and in winter, with the product of the mineral of the mill, for transshipment at the mine, via the Mineral Range Railroad to the smelting works at Hancock. The railroad, for the greater part of the way, passes through woodlands, and is without cuts, so as to prevent any drifting of snow. It is possible to keep it clear with a snow-plow, pushed by the weight of a heavy ore-train behind it. At the foot of the incline, the cars are carried by rope drawn by a special engine to the bins of the two mills, the Calumet on the right and the Hecla mill on the left, both being on the bank of Torch Lake, accessible to water transportation in the summer.

The mills are now in process of reconstruction on a scale commensurate with the capacity of the mine. When completed, the plant contemplated will be based upon the crushing capacity of ten Leavitt stamps, with one in reserve at each of the mills, making twelve in all. These ten stamps, each of which will have an average crushing capacity of 225 tons a day, will represent an annual demand for ore of 675,000 tons, equivalent to an output per annum of fully 30,000 tons of ingot on the basis of 4·5 per cent. rock. The average of the rock in 1883 was slightly above this. As at the mine, this expansion of the plant is to be carried on while the existing equipment is keeping up its present average record of 2,100 tons per month of mineral. At present, there are in the Calumet mill two Leavitt and three Ball stamps, and in the Hecla mill two Leavitt and one Ball head, one of the latter class being removed to make way for an additional Leavitt stamp. At the Hecla mill, an extension is now building, and the foundations will be put in in the course of the summer for three additional Leavitt stamps, for which a part of the machinery is now on the ground; while, in the Calumet mill, the three Ball heads will be similarly displaced. With the present equipment of four Leavitt heads, having a capacity of 225 tons a day, and four Ball heads, averaging 165 tons per day, approximately, the mill treated an average of 1,411 tons a day during the month of May, making 2,265 tons of mineral during the month. The Ball heads have been repeatedly described, and need no special mention now. The Leavitt heads will be referred to in detail in a paper by Mr. Coggin, manager of the mill, before the American Society of Mechanical Engineers. Mr. Coggin has made their works a special study, and has devised an ingenious method of determining the velocity of the piston at any part of the stroke, which, in connection with a thorough system of indicator diagrams, has been a valuable guide in carrying the machine to its present high standard of efficiency.

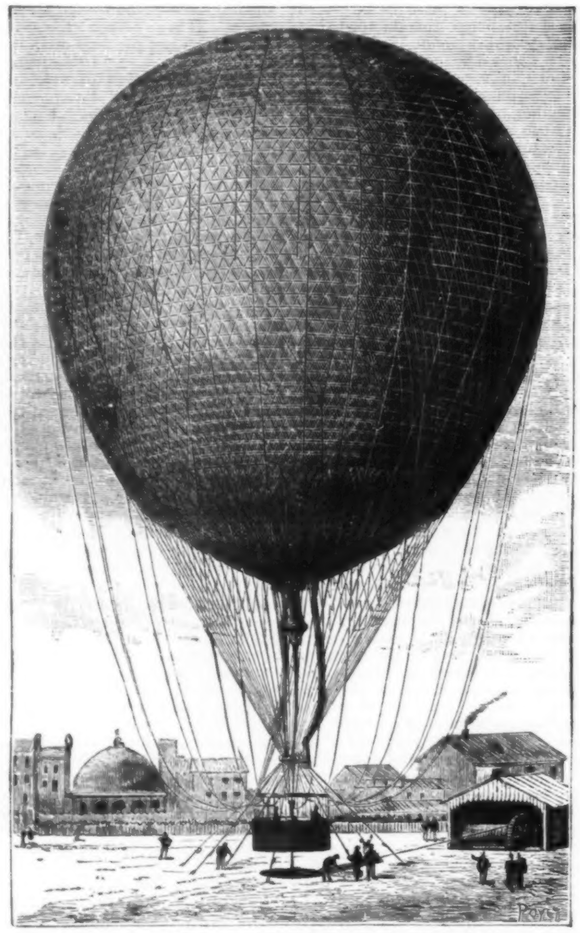
The valve gear has been somewhat modified, and other changes have been made that have all contributed to reach the saving of over 30 per cent. in steam consumption, as compared with the Ball stamp. One of the Leavitt stamps has reached a duty of 234 tons a day. The Leavitt stamps are run with a steam pressure of 90 pounds, cutting off at about two-tenths, with a receiver pressure of 55 pounds, making 90 blows a minute. The velocity of the piston is, for the greater part of the blow, about 17 feet, the weight of the shoe being, when new, 600 pounds. It wears down to make half its weight in from 5½ to 6 days. The rock is crushed through a $\frac{3}{16}$-inch screen, made of steel plate, being the "common" steel of the Crescent Steel Works, Pittsburg. The new plan contemplates the erection for each head of four sets of washing machinery for each stamp, each set consisting of four Coggin separators, the principle of which was described in a recent paper before the American Institute of Mining Engineers. In the Hecla mill, there will be 168 Collum jigs for dressing, and 96 for rejigging; while the Calumet mill will have 112 machines for dressing and 64 for rejigging. In each mill, there will be six 5-stamp batteries of the California pattern, with 750-pound stamps and 6-inch drop, which will be used for restamping and rewashing the waste sands. For the treatment of slimes, the ordinary round rotating buddle, with water-spray discharge, has proved more efficient than the Evans buddle generally used in Lake Superior copper dressing-works. The sands are to be elevated by the great sand-wheels, a description of which has been already published. One of these was already in place, and was being equipped to take its place in the plant.

As in all the other parts of the enormous plant, the stamp-mills are equipped with duplicate machinery, so that there will be no possibility for stoppage of work, through breakdowns, however unimportant. Accordingly, there are two driving-engines, one the "Erie" and the other the "Wabeek," the latter having formerly served as the hoisting-engine on one of the Hecla shafts. The Erie is both a driving and a pumping engine, being of the compound Leavitt vertical type. It has an 11½-inch high-pressure cylinder, a 24-inch low-pressure cylinder, and 4½-foot stroke. With 100 pounds steam, and running at a speed of 46½ revolutions, it develops 200 horse-power. With two 16¼-inch plungers, and 23-inch buckets, it has a pumping capacity of 10,000,000 gallons. It drives all the washing machinery in the stamp-mills and tail-houses by wire rope transmission, the main rope, which runs on a splendid sheave 13 feet in diameter, running at a speed of about a mile a minute. The "Wabeek" will be the main driving-engine, being just in the course of erection after some alterations. It, also, is a Leavitt compound engine, with 22¾-inch high-pressure and 38-inch low-pressure cylinders and 5-foot stroke, and when running at 45 revolutions will develop over 600 horse-power. The main pumping-engine is the "Ontario," a Leavitt compound engine with 17¼-inch high-pressure cylinder, 36-inch low-pressure cylinder, and 5-foot stroke. Running at a speed of from 20 to 30 revolutions a minute, with steam at a pressure of 100 pounds, it is capable of pumping 20,000,000 gallons of water a day. As a reserve, the water-works possess a Brown 18 by 48 horizontal engine, geared to a pump having a capacity of 20,000,000 gallons a day, when running at 25 revolutions a minute, the pump having a 6-foot stroke and 36-inch plunger. This plant is furnished with steam by a nest of "Elephant" boilers, 30 inches in diameter and 44 feet long. A new boiler, built by the Dickson Manufacturing Company, of Scranton, is to be put in, having a 90-inch shell, being 34 feet long, and with a heating surface of 2,800 square feet. It is rated at about 700-horse power. For the Calumet stamp-mill, there is a plant of "Elephant" boilers, while the Hecla mill is furnished with steam by four locomotive boilers, 6 feet 8 inches in diameter and 32 feet long, with 1,800 square feet of heating surface in each. The mill has a fire-engine and fire service, a machine-shop and a cooper-shop. It is accessible by boats drawing 13 feet of water, and is the main receiving station for coal and machinery, and the principal shipping-point by lake of "mineral." The work is thoroughly systematized.

The tailings run about from 0·8 to 0·9 per cent. of copper, and some of the sands from 1·5 to 2 per cent. Professor Richards, of the Massachusetts Institute of Technology, last year began a series of experiments looking to the recovery of a part of the copper thus lost, but has not as yet completed them.

This brief sketch may serve to convey some idea of the magnitude of the operations of the greatest and the most successful metalliferous mine in the United States, and may aid in forming some conception of the brilliant future still before it. For the richness and magnitude of its ore-body, for developed reserves, for completeness and efficiency of its mining and crushing plant, the high quality of its product, the low cost of production, and its exceptional financial position, it stands unrivaled among the mining enterprises of the world. The credit for having carried the mine to its present point is due to the concerted efforts of Prof. A. Agassiz, the President, and his staff at the mine, Mr. J. N. Wright, Agent; Mr. J. Duncan, Assistant Superintendent; Captains Hoatson, Daniels, and Wills, in charge of the underground work; Messrs. L. S. Woodbury and J. Ramsey, the former mechanical engineer of the Hecla mine and in charge of the machine-shop, and the latter in charge of the Calumet machinery; Mr. F. G. Coggin, superintendent of the stamp-mills; and Captain West, formerly of the Coast Survey, who has systematized the topographical work and the underground surveying of the property of the company. Mr. E. D. Leavitt, Jr., of Cambridgeport, Massachusetts, is Consulting Engineer.

We cannot close without referring to the relations of the company with its 2,000 employes and men, the majority of whom live in cottages in Calumet, let by the company at a nominal rent, while a part occupy dwellings in the adjoining village of Red Jacket. The company has built a schoolhouse, in which 1,400 children are taught, and has established a relief fund in which employes pay 50 cents a month, the company doubling the amount thus raised. Out of this fund, medical attendance, either at the residence or at the hospital, is provided, together with free medicines, certain sums being paid monthly to subscribers during sickness, to those disabled, and to the widows of those killed. This fund is now an accumulated reserve of about $40,000.



THE CAPTIVE BALLOON AT THE TURIN EXHIBITION.

THE CAPTIVE BALLOON AT TURIN.

The captive balloon was inaugurated at Turin on Monday, April 14, and ascensions were made with success up to Sunday, the 27 of the same month, the day of the inauguration of the exhibition. At three o'clock in the afternoon, the aeronauts, seeing that the state of the atmosphere was threatening, stopped operations and made the passengers who had entered the car dismount therefrom. At thirty-five minutes past four, the balloon, which had been fixed to its anchorages, was struck by a flash of lightning in its equatorial part. The combustion was instantaneous and there arose a heart-shaped column of fire, nearly three hundred feet high, which lasted about twenty seconds.

Messrs. Eugene and Louis Godard, the aeronauts of the captive balloon, started at once for Paris, where, in ten days, they had cut out, sewed, and provided with cordage a new balloon of pongee of a capacity of 4,510 cubic meters. The diameter of the sphere is 20·5 meters. The fabric weighs 80 grammes per square meter, and it resists a pressure of 12,000 times its weight. The balloon is double, and is provided at its lower part with an air pocket for completely inflating it when it is resting upon its anchorage, and for preventing such an accident as put an end to the operations of the Parisian captive balloon of 1879. It weighs, all varnished, with its valves, 490 kilogrammes; the netting weighs 214, the rigging 101, the suspension hoop and accessories 76, and the car 273. It is always rigged so as to be able to make a free ascension, and consequently carries a 51 kilogramme anchor, an anchorage rope of 25 kilogrammes, and a guide rope of coir, 850 meters in length, weighing 58 kilogrammes. The valve is provided with a 5 kilogramme cup for preventing the accumulation of rain at the upper part, and for preventing the sun from injuring the India rubber. The valve is 95 centimeters in diameter, and is held by four rubber bands that are independent of one another and 12 centimeters in width. It is very easily maneuvered by means of a cord that passes through a special pipe which traverses the air pocket, and it opens under a pressure of 15 kilogrammes. The air enters and leaves the pocket, which has a capacity of 450 cubic meters, through a special pipe 8 centimeters in diameter and ten meters in length. This bag may be inflated by two men, with an ordinary bellows, in five minutes. The cable is 350 meters in length, weighs 350 kilogrammes, and is conical. Its upper diameter is 45 millimeters and its lower 35. It winds around a windlass 2·25 meters in diameter and 3·5 in length. The drum is not spirally grooved like the one used with the Paris balloon. It is actuated by two Weyher and Richemond engines, which are perfectly independent, which possess each its own generator, and which are each of 18 horse power. The tunnel is replaced by an excavation in the earth. The well is three meters in diameter, and the car is 3·10 meters. The latter is cylindrical, and open at the center like that of the Paris captive balloon. The ascensions were made with from twelve to fifteen persons. The universal pulley is according to the Giffard system. The Godards relieve one another at each ascension, so that there is always one aeronaut on board. The price of an ascension is 10 francs, and the entrance fee is one franc.

This new balloon was inaugurated on the 31st of May, at half past three in the afternoon. The Messrs. Godard made the ascent alone in order to test the apparatus. Immediately afterward the members of the Exhibition Committee on Fetes, Count De Sambuy, Count De Villanova, etc., accompanied by Captain Julhes, a French aeronaut, Mr. Peyrot, a Turin amateur—in all 15 persons—entered the car and ascended to a height of 300 meters. Then the paying ascensions commenced, and continued the following day with the greatest success, despite the wind and rain.

The view is a splendid one; there can be seen the course of the Po, the entire city of Turin, and many Alpine summits that are hidden from sight on earth by the outlyers of the chain.

On the occasion of the Italian national fete, the Messrs. Godard decided to make a free ascent in order to demonstrate that their captive was as capable of traveling with as much facility as an ordinary balloon. The experiment was a perfect success. It took but a few instants to detach the cable, close the central part of the car with a wooden disk, place in the hold thus constructed cloaks, coverings, awning, anchors, instruments, etc., and put on board 800 kilogrammes of sand.

The start occurred at seven o'clock exactly, amid cries of "Vive l'Italie! Vive la France!" and in the presence of an immense multitude, which filled the inclosure that had been set apart—the Massino d'Azeglio court yard and environs.

The balloon hovered for a quarter of an hour over the city at an altitude of from 1,600 to 1,200 meters. An aerial current then carried the travelers in the direction of the Po. At half past seven the balloon was suspended perpendicu-

larly, at an altitude of 1,700 meters, above the regatta, which was interrupted for a few moments. After this, continuing its ascent gradually, it drifted toward the mountain and soon reached an altitude of 2,200 meters, its maximum. The thermometer, which stood at 18° at the start, had fallen to 8°. At this moment flashes of lightning and clouds of wonderfully picturesque effect were observed over the snowy peaks of the Alps. The balloon was then hovering over Chievi.

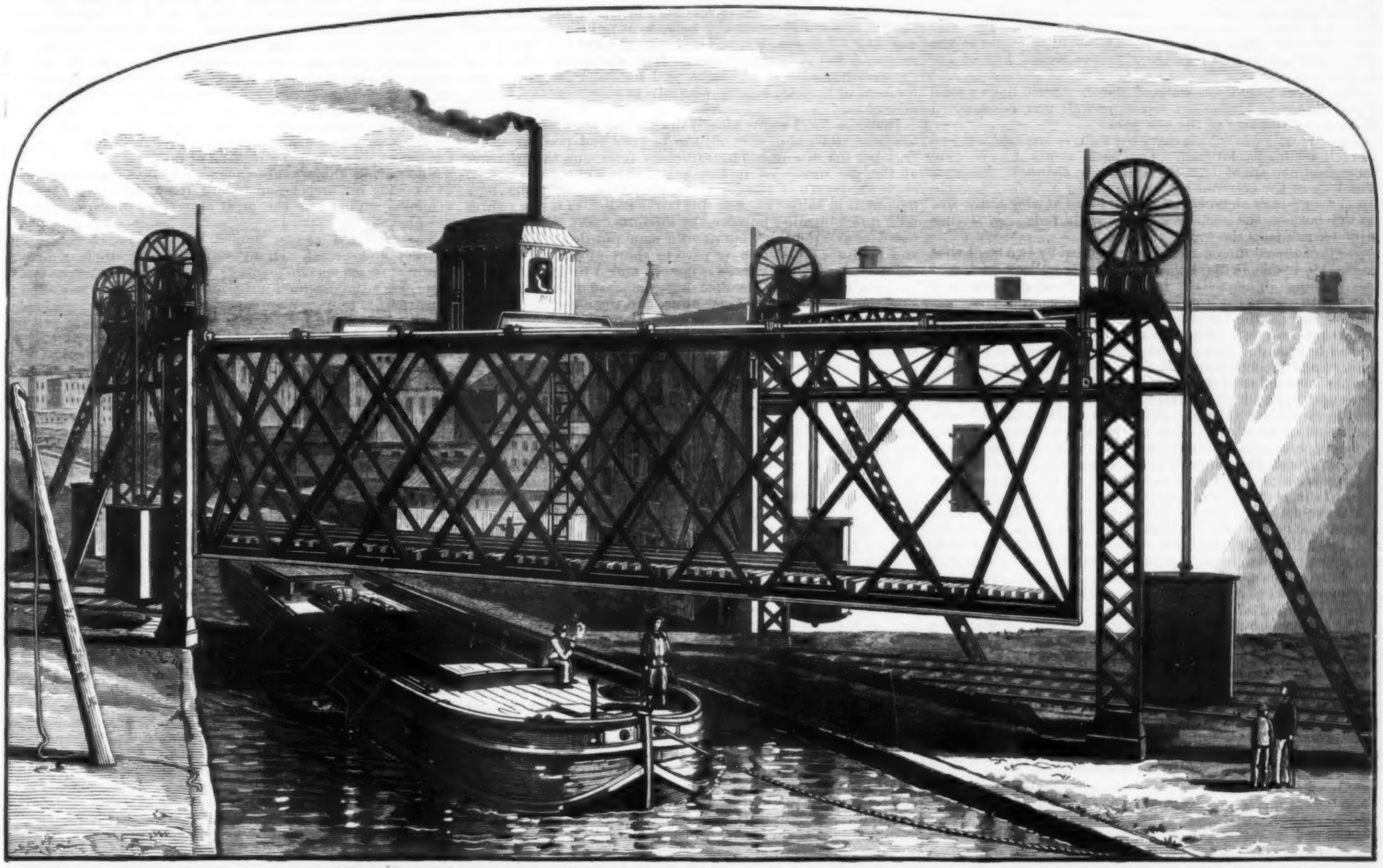
During the descent an under current carried the balloon in the direction of the Po, and allowed it to sail for a few moments along the Basilic of Superga (in which are interred the kings of Piedmont) and permitted the aeronauts to admire all the architectural details thereof.

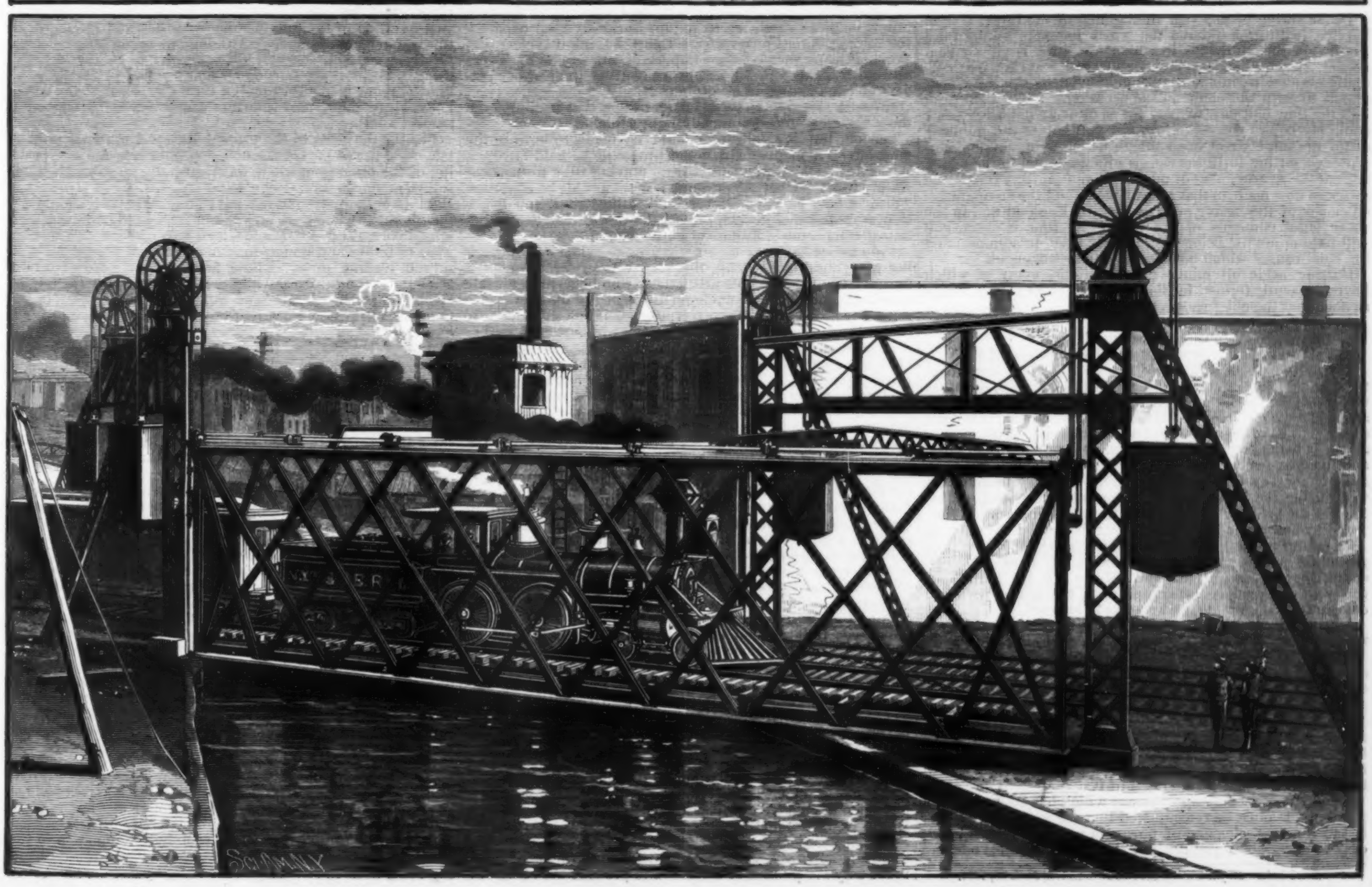
Continuing its descent, the balloon for a second time traversed the Po, over the Madonna del Pilone; and the car, being near the earth, was soon being towed by peasants who had seized the guide-rope. So the aeronauts had no need to cast anchor. The landing was effected at 9 h. 2 m. at Borgho Vinchiglia Cassina Canessa, the lands of the banker Treves, brother of the director of the *Illustration Italienne.* There were eleven persons on board, viz.: Messrs. De Fonvielle, Fortier, Guidini, Chomet, Vallod, Romeuf, Julhes, two ladies, and the two Godards as aeronauts.

The captive balloon was inflated again Sunday, June 8 The operation was begun at 4 o'clock in the morning and finished at 2 o'clock. Two successive ascents were made, with an ascensional force of 1,000 kilogrammes and with 15 persons on board. The sky having suddenly became covered with clouds toward Lombardy, and several peals of thunder having been heard, the ascensions were discontinued at 5 o'clock, to the great dissatisfaction of the numerous assemblage. But the ascensions were continued on the following days with great success. Yet they were interrupted on the 10th by very severe storms, and an intense wind that the balloon resisted perfectly, owing to the air compensator, whose action was very effective. This balloon is not only contributing to the success of the exhibition, but is rendering genuine services to meteorology. Father Denza, president of the Meteorological section of the Exhibition and of the Italian Meteorological Society, and Mr. Ragona, director of the Observatory of Modena, came last week to organize a series of observations from the car. We shall keep our readers informed as to the results obtained.—*La Nature.*

LIFTING BRIDGE FOR DOUBLE TRACK RAILWAY.

THE line of the New York, West Shore & Buffalo Railway crosses the Oswego Canal at Syracuse at a point where peculiar local conditions would not admit the use of a pivot bridge. To overcome these difficulties the lifting bridge illustrated was designed; and to freely allow boats to pass, it is lifted to a height amply sufficient to accommodate travel. No delay is occasioned, as the operation of lifting takes but thirty seconds, and the bridge can be so nicely adjusted by means of the counterweights that the work required of the engine is comparatively light. An exact balance is not





NEW YORK, WEST SHORE, AND BUFFALO RAILWAY.—LIFTING BRIDGE AT SYRACUSE.

aimed at, as the bridge when down is disconnected from the lifting machinery, and is held firmly on its seat by a weight of several tons, and the lifting of these few tons is, practically, all that the engine has to do. The location of the road is such that the bridge makes an angle of 38 degrees with the center line of the canal.

The extreme length of the truss is 94 feet, the extreme height 23 feet, and the extreme width 30 feet and 4 inches. Each of the top and bottom chords is composed of two 3 by 3 by $\frac{3}{8}$ inch angles, and two vertical plates 12 inches wide and $\frac{3}{4}$ inch thick, placed $13\frac{1}{2}$ inches between rivets. The top chord is strapped by a lattice on the top, and the bottom chord by a lattice on the bottom. The web of the trusses is composed of angles 2 by 5 by $3\frac{1}{2}$ inches, two being placed parallel but on opposite sides of the chords. In order that the diagonals running in different directions will not interfere with each other, one pair of angles is riveted to the outside of the plate of the chord, and another pair to the inside of the plate. Each pair of angles is latticed. The end posts are the same as the chords, with the addition of a $\frac{5}{8}$ inch plate. The floor beams are plate girders 28 inches deep and placed 9 feet $3\frac{3}{8}$ inches between centers. The stringers are 12-inch I beams, and upon them rest the ties. The end floor beams are plate girders of the same dimensions as the others, and are placed parallel with the center line of the canal.

The bridge rests upon walls of masonry built upon a solid foundation, and a masonry retaining wall was constructed along the water side of the tow path.

The end columns which carry the pulleys are made of two 15-inch channels, latticed. The back struts for bracing these columns are of two light 15-inch channels, latticed. The tops of the columns are connected by a stiffener, made up of two 8-inch channels on top and two of the same size on the bottom, the web being of 1-inch rods. A similar stiffener connects the tops of the struts.

Each of the counterweights is suspended by two steel wire cables $1\frac{3}{4}$ inches in diameter, carried over pulleys on top of the columns. The weight is obtained from pig iron and slag put in a wrought iron box having a cast iron yoke extending across the bottom, and to which the ends of the cables are fastened. The other ends of the cables are attached to each end post of the bridge. Attached to each column and freely suspended from its upper bearing is a double threaded steel screw $3\frac{1}{2}$ inches in diameter and 2 inches pitch, and long enough to reach a short distance below the top chord when the bridge is down. To each end post and upper chord of the bridge is riveted a bracket carrying a phosphor-bronze nut through which the steel screw passes. This nut forms the center of a bevel gear, and each one of these gears is actuated by a bevel gear at the ends of two lines of shafts placed on the upper chords of each truss. The shafts are driven by two 8x8 inch engines coupled at right angles, one revolution of which gives the nuts a half turn and raises the bridge one inch. When the bridge is lowered, the screws disengage at their upper bearings and allow the bridge to adjust itself to the masonry.

The machinery is located in the center of the top of the bridge.

The bridge is built entirely of iron, and weighs, with the machinery, 146 tons; the counterweights weigh 138 tons. The height of lift from the bridge seat is $10\frac{1}{2}$ feet.

The bridge was designed by Albert Lucius, Engineer of Bridges, New York, West Shore & Buffalo Railway; and was built by the Hilton Bridge Company, of Albany, N. Y., the erection being supervised by H. L. Forte, C.E., New York, West Shore & Buffalo Railway. The machinery was constructed by C. H. Delamater & Co., of this city, after designs by their engineer, H. B. Roelker.

THE HEAVY GUNS OF 1884.*

By Colonel E. Maitland, R.A., Superintendent Royal Gun Factory, Woolwich.

In the spring of this year the Council of the Royal United Service Institution did me the great honor of asking for a lecture on the subject with which my work is chiefly connected, viz., ordnance. The Secretary of State for War cordially granted permission, and, moreover, most kindly consented to take the chair on the occasion. I felt, therefore, that the time had now arrived for as clear an exposition as I could lay before you—and through you before the public—of the present state of this subject, which is of national importance, setting forth the causes which had led to the necessity for the re-armament of our naval and military forces, the progress now made in that re-armament, and the comparative efficiency of the heavy guns of 1884 in England and in the other chief countries of the world. As time is short, you will pardon me for being exceedingly brief in summarizing the chief causes which have led to our re-armament.

Putting aside all minor considerations, many of which have frequently formed fertile matters of controversy, I state at once that the chief causes are three:

1. Improvement in powder.
2. Improvement in mechanical appliances.
3. Improvement in production of large masses of steel.

It will perhaps be said that if this be true, these considerations should affect other nations besides our own, and that the great Continental powers should be re-arming extensively also. To which I reply that this is exactly what they are doing, and have been doing for some time past. This re-armament is being carried out rather more gradually than ours, and the changes they are making are less radical, but none the less are they thoroughly re-arming. It may be admitted that during the latter part of the seventies England fell behind in the artillery race, but not to the extent that is supposed by many who have not thoroughly studied the subject. As a matter of fact, the old short breech loaders of the Continent are just as obsolete now as the old short muzzle loaders of England, and up to about 1875 or 1876 the British artillery was as good as anybody else's. Then came a period of comparative stagnation, and we fell to leeward.

During the last three years we have been endeavoring to make up our leeway. One point we have in our favor. In a science which advances as fast as artillery has been doing of late years, the power which waits longest before committing itself to a new manufacture has the best of it, always supposing that it is not caught napping by an important war. It is not necessary to explore the debatable land of the might-have-been; it is sufficient for our purpose to know that we have not been caught napping by an important war, and I hope to show you to-day that the result is that having waited the longest we have got the best of it.

I come now to the improvement which has taken place in powder. It must be remembered that the weight of the gun is the limiting element of power in nearly all cases. It is easy to carry about powder and shot, but the gun is one and indivisible, and taxes the appliances of transport to the utmost. Hence, as long as guns have no special counterbalancing points of advantage or disadvantage, the proportion between the energy attained by the projectile and the weight of the gun forms a convenient way of comparing the excellence of various designs. It is briefly called "energy per ton." Conversely, the description of powder which enables a gun to realize the greatest energy per ton without exceeding the pressures which it is constructed to bear will be the best for that gun irrespective of the quantity of powder expended in producing that result. There are cases, no doubt, where the size or weight of the cartridge becomes a serious consideration, but as a rule it is of little importance when compared with the advantage of increased power. With breech loaders that powder is found to be the best which satisfies the following conditions:

It should fill the chamber of the gun as completely as is consistent with facility of loading.

It should burn slowly at first, till the projectile begins to move, gradually setting up just the maximum pressure suitable to the gun.

It should than burn faster and faster as the projectile travels onward through the bore, so as to keep up the pressure as long as possible, and give the greatest amount of energy. A low maximum pressure long sustained is the great desideratum of the artillerist, and no one will attain any measure of ballistic success who fails to recognize this fundamental maxim.

Diagram No. 1 shows clearly the amount of progress which has been attained in slowing the powder and producing energy per ton of gun. The ordinates represent the pressure of the gas measured in tons per square inch; the abscissæ show the length of travel of the projectile along the bore measured in calibers. The fine curve indicates the pressures with quick burning powder, the medium curve with medium powder, and the thick curve with slow powder. The quick and medium powders were used in short guns, and the dotted portion of their curves is merely added to show how little gain would have resulted from increase of length. The slow powder is used in long guns, and the amount of pressure kept up to the muzzle indicates that we can go still further in the direction of length with advantage. The area included by these curves of course represents the work done by the powder, nearly all of which goes to produce energy in the projectile. It at once becomes evident that to get an increased ratio of power to weight, we had to turn thickness of metal at the breech into length at the muzzle; that is, to lower the pressure in the chamber and keep it up longer in the bore.

We sometimes hear statements to the effect that the road to improvement lies in the direction of using very quick powders, and making enormously strong guns to withstand the highest pressures powder can give in a closed vessel, viz., about 42 tons per square inch. This system, from an engineering point of view, is no doubt right as causing the least consumption of fuel; but it is utterly and entirely wrong when seen from the artillerist's standpoint. The artillerist cares little for the amount of fuel consumed, but a great deal for the weight of the machine consuming it. Now, when guns are fired with powders giving different pressures, it is found that the rise in energy of projectile at the muzzle is not nearly in proportion to the rise in pressure in the powder chamber. High pressures are extremely capricious and uncertain in their effects, and no precise rule can be laid down; but taking our usual service maximum pressure with slow powder at $17\frac{1}{2}$ tons per square inch, and substituting an equal quantity of a powder violent enough to give 35 tons per square inch, I should not expect to realize an increase of energy of more than about 20 per cent., though the pressure has been doubled. But doubling the pressure necessitates doubling the strength of the breech, and hence of adding about 80 per cent. to the weight of the gun. Besides this, high pressures give rise to many inconveniences, the breech fittings and the firing arrangements are apt to be burred, set up, and jammed; the shell and shrapnel are liable to be broken up in the bore unless made so strong as to reduce seriously their capacity for holding bullets or powder. Hence I think it is clear that slowing the powder is a most important improvement. There are two reasons why this improvement in the powder renders breech loading an absolute necessity:

First, the guns have to be made so long that loading from the muzzle becomes practically impossible on service.

Second, the slow powder cannot be made to burn in the most effective manner unless the projectile be held fast by a strong band which prevents it from moving till a pressure of from 1 to 2 tons per square inch is set up in the chamber. This can only be done in breech loading guns, and hence they are capable of developing greater power than can be obtained from muzzle loaders of equal weight.

I am aware that two or three years ago, when breech loading was young in England, this view was strongly combated by some of our most able artillerists, who held that muzzle or breech loading *per se* made no difference in the power of a gun; but now I think its correctness has been established by frequent experiment, and will hardly be questioned. Here it may be seen how, by coming last to breech loading, England was able to build on Continental experience and improve upon it. In 1880 we were using for our heavy muzzle loaders either Waltham P^2 or German prismatic powder, which gave, when proved in the 38-ton muzzle loader guns, pressures of about 19 tons, and velocities of 1,560 f. s. Directly the Royal Gun Factory came to breech loading, the unsuitability of these powders became apparent to us, though the German prismatic powder was specially manufactured for Krupp breech loaders. The superintendent of the Royal Gunpowder Factory at Waltham was promptly asked to make a powder which should give about 800 f. s. velocity in the 38-ton gun, with a pressure of not more than 5 tons, using the same charges as with the German prismatic. This modest request would probably have met with derision if regarded simply from an engineering point of view, as involving an absurd waste of fuel; but Colonel Brackenbury tackled the matter very successfully, and after some preliminary trials produced an admirable powder, which attained celebrity under the name of H_2. This powder was nearly useless for muzzle loaders, but when fired in heavy breech loaders gave by far the best results then known. A modification of it has now been introduced and issued for service as C_2; since that time the Germans have taken a fresh departure, and have quite lately produced a powder which seems to be a little better than C_2. It is known as cocoa powder, and its composition is a secret. The specialty of this cocoa powder is that although it lights with great regularity and burns very slowly at first, yet when the projectile has got fairly under way it burns with tremendous rapidity. In the 19-ton 9·2 inch guns it has about the same ballistic excellence as the best lots of C_2; that is, it gives about the same pressures and velocities all the way up the bore, but it takes only 170 pounds of the cocoa to produce the results attained by 200 pounds C_2. These charges give about 2,050 f. s. velocity to a projectile weighing 380 pounds, the pressure being about 17 tons in the chamber. Thus the extra 30 pounds of C_2 are required to give off gas as the projectile travels through the bore to balance the quicker final burning of the cocoa.

Darwin tells us, in one of his charming books, how the probosces of the Madagascar moths tend to lengthen in successive generations so as to reach the honey dew of the orchids, while the nectaries of the flowers tend to deepen continually to force the moths to push their heads in and exchange the fertilizing pollen. So we find in the struggle for existence, the guns growing longer and longer to get the best effects from the slow powder, while the powder tends to grow slower and slower to meet the wants of the guns, in accordance with the eternal principles of evolution.

The next point is the improvement made in the mechanical appliances of guns. With a breech loader the first necessity is a thoroughly satisfactory system of closing the breech. This was certainly not accomplished by any nation till after the Franco-German war of 1870. Krupp then entirely remodeled his breech fittings, and introduced the form now universal in his modern guns. The French Marine improved the details of their existing system in like manner, and the French land service, after a long series of experiments, retained their system of closing the breech, but adopted an entirely new method of obturation invented by De Bange, of the French Artillery, to whom I am very pleased to have this opportunity for expressing my gratitude. The great Elswick firm also adopted the French system of closing the breech, but applied a method of obturation of their own. Thus, during the seventies four really serviceable methods of working the breech and sealing the escape of gas became available, and one of the great objections to breech loading disappeared.

The two first causes named, *i. e.*, the improvements in powder and breech actions, settled the questions of breech loading *versus* muzzle loading; the third cause of re-armament, viz., the production of steel in large masses, affects construction only. Were large masses of steel not available, we should still have to re-arm with breech loaders; but the old system of construction would, no doubt, be retained, and the change we have made would not be of so radical and complete a character.

In bringing forward the army estimates in March, Lord Hartington stated to the House of Commons that, "With regard to the supply of heavy guns for the navy, fair progress has been made in the present year. During the present and the past two years, we have been undergoing a double transition: first, from the muzzle loader to the breech loader; and in the next place, in the material, from wrought iron to steel. Twenty years ago another transition took place, which was of an exactly opposite character. Twenty years ago we reverted from the breech loader, the more complicated gun, to the muzzle loader or more simple gun, retaining the same material of manufacture. At that time the largest guns in the service were of 7 tons weight, firing 30 pounds of powder. In the change from the muzzle loader to the breech loader the guns are of 40 tons weight, firing 400 pounds of powder. The committee may therefore imagine what has been the difficulty, and the necessity there has been for hesitation and caution in undergoing such a transition under such circumstances. The main difficulty has been to obtain sufficiently large steel forgings for these immense weapons. There are in France and Germany several firms which have been able to supply steel forgings of the size and also of the quality required for these guns; but up to the present time the demand has been a new one to the English trade, and there has been great difficulty in obtaining from the English trade steel forgings of the size and quality required."

This precisely sums up the case, and shows how the improvements introduced into the manufacture of large masses of steel have effected our re-armament. I speak in general terms of the material of which our new guns are made simply as steel, because I wish to avoid entering at all upon the vast question of the innumerable qualities and attributes of this wonderful substance. Although its manufacture is still far from perfect, and will probably not be reduced to anything like an exact science for many years, yet sufficient is known about it to afford matter for many lectures, and I cannot venture in the short time now at our disposal to touch the subject at all.

For the purposes of the present lecture I must ask you to take steel as steel. On the occasion just referred to, speaking of the progress made in our re-armament, Lord Hartington went on to say: "We have supplied, or in a few days shall have supplied, to the navy 10 guns of 43 tons and 12-inch bore, 18 of 18 tons and 9·2-inch bore, 8 of 18 tons and 8-inch bore, 171 of 4 tons and 6-inch bore; besides 190 smaller guns of 2 tons and under, making a total of nearly 400 new breech loading guns. Those first in hand were of mixed steel and wrought iron, while the later guns are entirely of steel. There has been some advantage in the delay in the adoption of the new pattern of breech loading ordnance. We have had the advantage of the experience gained by France and other powers, and it is believed that we have now obtained a system of breech loading of a simple and efficient character. In addition to the guns I have enumerated, there are in hand, under construction for the navy, 3 guns of 110 tons, 4 of 63 tons, and 3 of 43 tons, besides a very large number of smaller guns in various stages of progress. At the same time there are under construction for the land service 10 guns of 43 tons, 4 of 26 tons, and other guns of smaller size."

This brings the state of affairs down to about three months ago, since which time the manufacture has been steadily proceeding, but of course no important change has been made.

I will now endeavor to give you some idea of the relative excellence of the latest types of heavy guns at home and abroad, selecting three separate features for comparison as being of a crucial character. These features are:

1. The system of breech loading and obturation.
2. The construction.
3. The power.

First, the Krupp system of breech loading. This consists of a round backed wedge, which is pushed in from the side of the breech and forced firmly home by a screw provided with handles; the face of the wedge is fitted with an easily removable flat plate, which abuts against a Broadwell ring let into a recess in the end of the bore. On firing, the gas presses the ring firmly against the flat plate and renders escape impossible as long as the surfaces remain uninjured. When they become worn the ring and plate can be exchanged in a few minutes. The vent passes through the facing plate to the rear of the wedge. The gun is fired by a frictional vent sealing tube, which is screwed by the fingers into the vent and unscrewed after firing. This form of breech loading has a decided advantage in loading by hand at elevation,

* Read before Royal United Service Institution, June 20, 1884.

which may sometimes be required, as the weight of the wedge is not working against closing the breech, as in the case with interrupted screw systems. It has, however, several counterbalancing disadvantages; the handles at the side are very liable to be damaged by the enemy's fire or otherwise; the length of the gun is necessarily greater in proportion to the length of bore; the recess for the Broadwell ring somewhat weakens the wall of the chamber; the gun can be fired even though the wedge is not pushed properly home; and the breech has to be opened after a misfire, or if the tube is exchanged without opening the breech, it may be unsafely replaced; moreover, the longitudinal strength depends on the soundness of the single piece of steel through which the wedge passes. Still it must be admitted by all unprejudiced persons that the Krupp ordnance, taking system, construction, and material altogether, are not easily to be beaten.

Secondly, the French marine system. Here the bore is continued to the rear extremity of the piece, the breech end forming an intermittent screw—that is, a screw having the threads intermittently left and slotted away. The breech block has a similarly cut screw on it, so that when the slots on the block correspond with the untouched threads in the gun, the block can be pushed straight in, and the threads made to engage by part of a revolution. In the French marine the escape of gas is stopped very much as in Krupp's system; a Broadwell ring is let into a recess in the end of the bore, and a plate on the face of the breech block abuts against it. The vent bush passes through the screw, and is fitted with a lock at the rear for firing percussion tubes. It is so arranged that the gun cannot be fired unless the breech block is screwed properly home. The parts are all protected behind the gun, and the only disadvantage seems to be the recess required for the Broadwell ring, which weakens the wall of the chamber, and necessitates a corresponding increase in the area of the face of the breech screw upon which the gas acts, thus increasing the longitudinal strain beyond that unavoidably due to the size of the powder chamber. As in Krupp's guns, the parts liable to wear are very dependent for their duration on cleanliness and freedom from dust and grit; but when worn they are quickly and easily replaced.

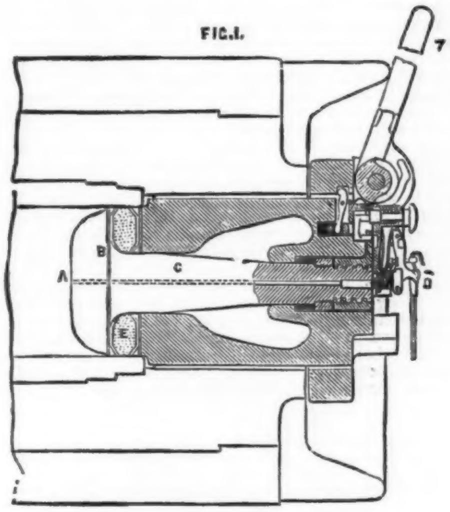
Thirdly, the French land service system. Here we have the interrupted screw as in the marine, but the escape is sealed in quite a different manner. A stalk passes through the breech block, its foot being secured on the exterior. The stalk has a mushroom shaped head projecting into the bore. Round the neck of the stalk, just under the mushroom, is a collar or pad of asbestos secured in a canvas cover. When the gun is fired, the gas presses the mushroom against the asbestos collar, and squeezes it against the walls of the bore. It is found that this cuts off all escape. In this obturation we have no weakening of the walls of the gun, and no increase of longitudinal strain, but the bore is slightly shortened by the protrusion of the mushroom head into the chamber. Its great advantages are that the soft pad adapts itself to the gun surface against which it presses regardless of dust, grit, bruises, or other imperfections. The parts can be replaced easily and quickly; they are also light and inexpensive. The vent passes through the mushroom head and stalk to the rear, and the gun is fired by a simple friction tube, pulled from the side. This arrangement is defective, as the gas soon wears out the vent, necessitating a new mushroom; while the frame of the firing tube is blown forcibly out, clinging to the hook of the lanyard and proving a source of inconvenience to the firer.

Fourthly, the Elswick system, which consists of a flat backed cup abutting against the slightly rounded face of the breech plug. The lips of the cup rest against a copper ring let in the walls of the bore. On firing, the gas presses back the cup against the rounded end of the breech block, and thus forces the lips hard against the copper ring. The cup takes up very little room in the chamber, but is very sensitive to grit and dirt, so that, as well as the copper ring, it requires renewal at uncertain and often frequent intervals. The cup itself can be replaced in a few minutes, but the copper ring takes several hours to extract and renew; the instructions given lay down that a special cup is to be inserted and two rounds fired with it so as to fully expand the ring, which is then to be trimmed to fit the reserved cups. The firing arrangement consists of a removable needle holder which carries a percussion tube nearly to the end of the bore; the needle passes from the tube to the rear of the breech screw, and is there struck by a hammer actuated by a lanyard. There is a safety arrangement which prevents the hammer from striking the needle till the breech is properly closed. The chief objection to this plan of firing lies in the difficulty of training men to pull the lanyard in such a way as to give sufficient force to ignite the detonator.

Fifthly, the breech action we began with, viz., the French interrupted screw. The Elswick obturation was selected. I do not know exactly why, but I believe under the idea that the gas would not be able to eat its way between the cup and the copper ring, which therefore would never require to be taken out and renewed. We changed the firing arrangement to one having a removable vent head carrying a friction tube; it was provided with a safety arrangement which prevented the lanyard from being hooked to the tube till the breech was properly home. As experience showed that the copper ring did require to be renewed from time to time at very uncertain intervals, and as this was a serious operation, experiments were forthwith instituted with the De Bange obturation, and with such success that it speedily established itself, and was adopted for all the new guns—*vide* E, Fig. 1.

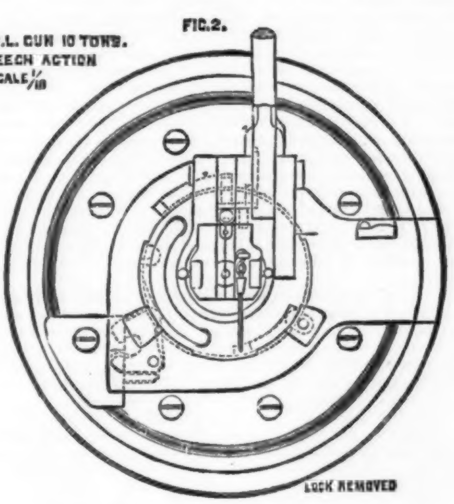
Sixthly, our present breech closing arrangement, as applied to the steel 7-inch guns—*vide* Figs. 1 and 2. It has one great theoretical defect—it appears extremely complicated. This, however, is not quite so serious as it seems at first sight, for not only is it difficult for the parts to get out of order, but any or all of them can be exchanged in two or three minutes. The vent, A, passes through the mushroom, B, and stalk, C, as in the French land service gun; a clutch box on the rear end of the stalk carries a percussion lock, D, similar to that of the French marine. The safeguards which cause the apparent complication of the action are numerous. The tube cannot be struck by the hammer, even though the lanyard be pulled, till the breech is screwed home. Should there be a misfire, the slide is drawn back to permit the exchange of the tube, and the new tube cannot be fired till the slide is pushed properly over the tube again. Should the slide not be properly pushed over the tube before loading, the action of closing the breech forces it home; but should the tube be sticking so far out of the vent that forcing the slide home would break it, and perhaps explode the detonator, the slide yields, and the attempt to screw the breech block home reveals the error. Should the thumb slip in cocking, the hammer will not fall on the striker so as to explode the tube, but on a projection which is removed when the lanyard is pulled. Thus, by coming last, we have been able to select and combine the best features of the French systems, land service, and marine, making, perhaps, a few trifling improvements of our own.

FIG. 1.



7 IN. B.L. GUN 10 TONS.
BREECH ACTION
SCALE 1/10

FIG. 2.



The next point is construction. The experimental breech loading guns first designed followed implicitly the system of construction which owed its origin to Sir W. G. Armstrong, and which, though subsequently modified in several ways, in the Royal Gun Factory, will ever be associated with his name. This was the system of wrought iron coils shrunk over each other and lined with a steel tube, which had been adopted for the long discarded vent piece breech loaders, and afterward for the muzzle loaders up to and including the 80 ton and 100 ton guns. This construction had a long day of success, and its cult was not rudely disturbed till the close of the seventies. Early in the eighties—the revolutionary eighties—however, it was found impossible to vie any longer with the stronger material which was in general use in Germany and France.

Guns of wrought iron could not be made to possess the same power as guns of steel without an important excess of weight. Efforts were made to preserve the advantages of the coil construction by employing a mild steel largely alloyed with manganese, which could be made to weld satisfactorily; and experiments were carried out in the Royal Gun Factory with wrought iron coils, steel coils, and forged steel hoops. These resulted in the complete victory of the forged steel hoops, and in April, 1882, the first English heavy breech loader, a 12 in. of 43 tons, entirely of forged steel, was proposed by the Royal Gun Factory. The matter was so important that it formed the subject of an elaborate inquiry by the Ordnance Committee, who took evidence from the principal experts of the country, and whose recommendations have proved of great value to the service. They decided upon a general type of gun, which was based upon a design submitted by the Royal Gun Factory on the 21st of July, 1882, and all the guns since made for the British Government have conformed substantially to this type. But before describing it, I will take some of the Continental guns, the constructions of which are earlier in date. First the 70 ton Krupp gun of 1881. The great German manufacturer keeps the sections of his gun a profound secret, and hence the drawing I am going to point to next must not be taken as authentic. During a visit to Essen in 1881 I saw the parts of his guns in the machines and lying about, and I hope he will forgive me for having taken furtive measurements with an umbrella and by the eye sufficient to enable me to make a tolerably close guess at the construction.

It should be said here that the Russian heavy guns are either made by Krupp on designs of similar character to this, or copied by the Russians in their own steel. Krupp's latest design is for a heavy gun weighing 121 tons, and 35 cals. long—*vide* Fig. 3. I venture to fill in the construction on the assumption that no radical change has taken place in the Essen principles since 1881; but again this must be taken as guesswork as regards the actual dimensions of the parts. This is the heaviest gun in the world, and four are being made for the Italian land service. It will be observed that the tube forms a lining extending from the muzzle to the face of the wedge, and that it is recessed at the end of the bore to receive the Broadwell ring. Over the tube is shrunk the breech piece in which the wedge plays. Over the breech piece are shrunk several hoops. Every portion is made of the finest gun steel. In this construction the whole of the metal over the powder chamber comes into play to sustain the transverse strain, which is transmitted from the tube to the breech piece, and from the breech piece to the superposed hoops. Neither hoops nor tube, however, assist in bearing the longitudinal strain, which is entirely taken by the breech piece. I suppose Krupp has satisfied himself that this gives plenty of strength, and that there is no chance of a dangerous defect, but I confess I should prefer to have a second string with guns of such great size in case anything went wrong with the breech piece.

Secondly, the latest heavy French naval guns, the 34 cm. and 37 cm. of 50 and 70 tons respectively. The 34 cm. gun consists of a very thick tube or body strengthened with layers of hoops. As in Krupp's guns, the whole of the metal

FIG. 3 40 c/m (15·75 in.) B.L. GUN, 119 TONS KRUPP 1884

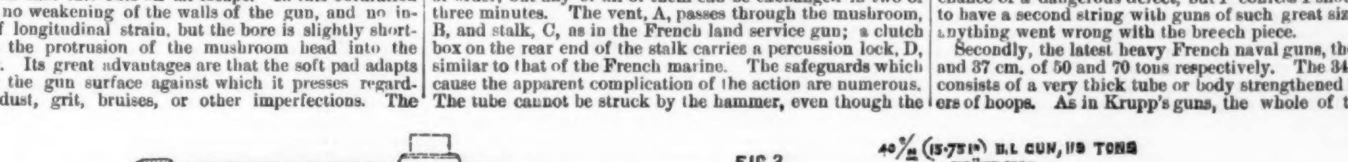


FIG. 4 16.25 in. B.L. GUN, 110 TONS E.O.C. 1884.

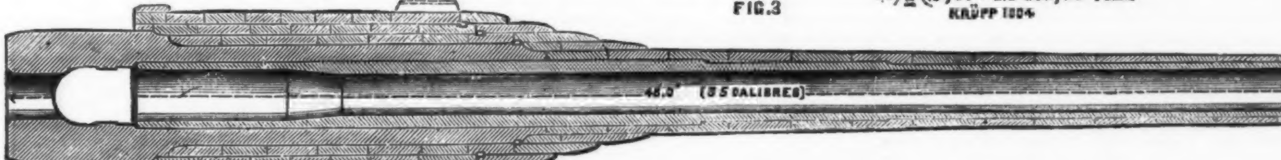


FIG. 5 13 5 in. B.L. GUN, 63 TONS R.G.F. 1884

ENGLISH AND OTHER HEAVY GUNS.

comes into play transversely, but the longitudinal strain is taken by the tube alone. Personally I do not like this construction. I think too much depends on the tube, and any failure of this part, which is, moreover, specially subject to the erosive action of the gas, would be disastrous in the extreme. Whether General Dard, the designer of this gun, found it difficult to obtain satisfactory forgings big enough to make the 37 cm. guns on the same construction I do not know, but Le Creusot and St. Chamond can turn out forgings of 70 or 80 tons weight, and therefore I am inclined to suspect that General Dard preferred to trust less implicitly to the tube in these larger guns, and therefore thinned down the central forging and introduced a breech piece between it and the hoops, which to my mind is a very decided improvement, as being put on with shrinkage it places the metal in a better position for resisting the transverse strain, and affords far greater security against longitudinal rupture. Every part is of steel.

Thirdly, the Italian naval 100 ton breech loader of 1882, manufactured by Sir W. G. Armstrong, Mitchell, and Co., of Elswick. In this construction the tube is in two parts, held together longitudinally by a key ring in halves. The breech screw plays in the tube, over which is shrunk a steel breech piece supported by two layers of thin hoops, and a thick outer wrought iron coil. The middle and forward parts of the tube are supported partly by steel hoops and partly by wrought iron coils. This construction was never repeated, although the experiments with it at Spezia were very successful. It is introduced here as showing with remarkable clearness the nature of the transition which has been taking place in construction.

Fourthly, I give you the typical design submitted to the Ordnance Committee by the Royal Gun Factory on 21st of July, 1882, and recommended by them to guide future manufacture. This particular gun weighs 12 tons, and is 8 in. in caliber. Here the tube is thin and extends to the rear only sufficiently far to receive the obturator. Over the tube is shrunk a breech piece, which is supported by exterior hoops. In this construction the whole of the metal assists in bearing the transverse strain, but the breech piece does all the longitudinal work. This is not particularly objectionable in a medium sized gun of 12 tons, but would, I think, be so in very large ordnance; as you will presently see, with our heavy guns further provision is made for taking the longitudinal strain. The tube which is subject to erosion by gas is relieved from longitudinal strain, and is, moreover, so thin that a crack in it would not imperil the safety of the gun; while the form given to the breech opening renders it easy to bore out the eroded surface after long continued firing, and to insert a thin lining into the tube itself, as shown by the dotted lines, thus giving the gun a fresh life.

With breech loaders on the interrupted screw system, the longitudinal strain is found to act most dangerously about the position of the front threads, and it will be seen that at this point the metal of the breech piece becomes thicker and stronger than in the more forward part over the chamber, while a strong hoop extending to the extreme rear of the gun clasps the breech piece tightly over the screw and prevents any tendency to open.

Fifthly, the Armstrong 100 ton guns now being made for the Lepanto, the great Italian war vessel. The design has superseded that of the 100 ton breech loading gun mentioned above, and has been kindly sent to me by Captain A. Noble.

Sixthly, in Fig. 4 we have the section of the Elswick gun of 110 tons. This magnificent piece of ordnance is being manufactured for the British Government at the works of Sir W. G. Armstrong, Mitchell, and Co., Newcastle-upon-Tyne. It is entirely of steel. The tube is thin, and extends only to the obturator, and the breech screw works in the breech piece, which is shrunk over the tube as in the typical design above mentioned. Three layers of hoops re-enforce the breech piece. Here also every part of the metal over the chamber assists in supporting the transverse strain. The breech piece is assisted in supporting the longitudinal strain by the peculiar distribution of the hoops. A long hoop provided with stout shoulders forms the rear part of the first layer. Its front shoulder engages the rear shoulder of a long hoop, which forms the front part of the second layer and carries a front exterior shoulder against which the trunnion hoop, forming the middle part of the third layer, abuts. Hence we have a direct pull from the trunnion hoop to the shoulder on the breech piece.

For the sake of clearness I speak of the trunnion hoop, but in reality there are no trunnions—the exterior of the hoop forms two rings which are held in a strong band attached to the slide. To prevent the inner tube from moving forward in case the friction between it and the breech piece should become relaxed on firing, a metal of the character of phosphor-bronze is run into a serrated recess at the front of the breech piece. In building up this gun the trunnion hoop forms a kind of watershed, so to speak, that is, all the hoops behind it are put on from the breech, and all in front of it are put on from the muzzle. To assist friction in keeping them in place, phosphor-bronze is run into a serrated recess under the trunnion hoop. It will be observed that in this design several important improvements have been made in the 100 ton gun manufactured for the Italians in 1882. The Lepanto gun shows an intermediate step in the transition. The tube is thinned down and fitted into the breech piece, which receives the breech screw. The joint in the front part of the tube is got rid of. The material of the gun is entirely of steel, cast and forged. The system of obturation is changed from the cup to the pad, and the powder chamber is made shorter and thicker. Fig. 5 represents the section of the 63 ton guns now being made in the Royal Gun Factory. They are entirely of forged steel, which, with the exception of some of the smaller parts, comes from Sir J. Whitworth & Co., who have, so far, met our requirements better than any other maker.

In this design the tube is thinned down at the breech, and the breech piece, which is shrunk over it, receives the breech screw, as in the typical gun of Diagram 15. The metal is disposed in fair conformity with the transverse strain expected, and considerable weight is saved in front of the trunnion ring. All the metal assists in taking the transverse strain, except a very small layer, of which only half assists, as will be seen presently. Over the breech piece a hoop extending the full length of the chamber is shrunk on, and the weakness of a joint at this important part is avoided. An exterior hoop of fair length re-enforces the breech still further. You will observe a novel feature in the disposal of the hoops so as to secure the greatest amount of longitudinal strain.

The hoops abutting against one another endways are linked together by outer hoops. The exterior of the inner hoop carries a ring which is slotted away so as to leave alternate projections and intervals. The interior of the outer hoop carries a corresponding ring, which is also slotted away, so as to leave alternate projections and intervals. The outer hoop, expanded by heat, is passed over the inner hoop, so that the projections pass through the intervals; it is then turned, so as to bring the projections of one hoop exactly in line with the projections of the other, thus preventing any longitudinal movement. The intervals are then filled up with long steel wedges, which are forcibly driven in. One wedge would be sufficient to prevent any circumferential shift, but all the intervals are filled up, so that the strain from the interior on firing is directly transmitted to the whole of the outer hoop. You see that half the metal of the layer represented by the thickness of the wedges is not available for resisting the transverse strain. This is made up by slightly increasing the thickness of the outer hoop. By this device the gun is stiffened at the joints, and held together longitudinally from the extreme breech end to a point far up the chase—an advantage in point of strength and safety possessed by no other design with which I am acquainted.

Coming last to steel breech loaders, England has been justified in fearlessly adopting the metal, which has been thoroughly tested by German experience. She has also adopted a construction which bears a certain similarity to the French, but is modified somewhat as in Krupp's guns. Having thus taken what seemed to be best of other people's, we have added a little of our own in the matter of locking all the parts of the gun together. It would be unpardonable in a manufacturer not to adopt what he thought the best, and if I saw anything that satisfied me better than this 63 ton design, I should certainly try to get it; hence you will, I am sure, pardon me for saying that I think that, coming last, we really have got the best forged steel construction known. I use this expression to avoid including constructions which involve the employment of wire, which may, perhaps, supersede those consisting entirely of forged steel. It is perhaps hardly correct to include them among the guns of 1884, as they are chiefly experimental; but I believe some have been made, and actually issued, for sevice to Chili, by the firm of Sir W. G. Armstrong, Mitchell, and Co. Competitive designs have been prepared for the War Office by the same great firm and by the Royal Gun Factory for guns of this kind, and I have received Captain A. Noble's kind permission* to show you a section of the 18 ton wire gun proposed by Elswick. The tube is thinned down inside the breech piece, which is shrunk over it, and receives the breech screw.

Instead of being re-enforced with steel hoops, the breech piece receives great transverse support from a steel flat wire or ribbon which is wound around it like thread on a reel, but at considerable tension. This wire breaks at 60 tons per square inch. Thin protecting hoops of steel cover the wire and form the exterior of the gun. Here all the metal over the breech assists in supporting the transverse strain, but the longitudinal strain falls entirely upon the breech piece. The great obstacle to the employment of wire in a gun has always been the difficulty of getting sufficient longitudinal strength; no means has yet been devised of putting on high class wire to give both longitudinal and transverse strength. A portion of the wire may be put on, as was done in one construction most ingeniously by Sir W. G. Armstrong, so as to give longitudinal strength, but then it becomes useless transversely. That device has been abandoned in this design, and hence the longitudinal strength is rather low. A Royal Gun Factory design was submitted at the same time. In this construction the tube extends the whole length of the gun, and receives the breech screw. It is protected from the erosive action of the gas by a thin lining, which extends from the obturator as far as necessary up the bore. The breech end of the tube is much thickened over the breech screw, so that this is the strongest part longitudinally. Over the chamber is wound a high class flat wire, which confers immense transverse strength, but does nothing longitudinally. This wire breaks at 100 tons per square inch. Over the wire are shrunk two long hoops of forged steel, which transmit the longitudinal strain from the rear end of the tube to the trunnions, by means of two systems of locked projections.

In this construction the whole of the metal over the chamber assists in supporting the transverse strain. The longitudinal strength is divided about equally between the tube and the outer hoops, and is ample. In considering the probability of forged steel construction being supplanted by those containing wire, it must be borne in mind that the lighter the gun in proportion to its power, the more work is thrown on the carriage in checking and absorbing the recoil. There is some doubt whether a practical limit has not already been reached in this respect with the latest patterns of forged steel guns; that is to say, any further reduction of weight in proportion to power may be found to necessitate more than a corresponding increase of weight to the carriage. Should experience prove this to be the case, there will be little advantage in the introduction of wire, except in certain special cases, such as siege howitzers, etc.

Our third and last point of comparison is the power developed by the various types of ordnance which have been brought before you. In this respect we have had nothing to learn from abroad. We owe much to the labors of the Explosives Committee, and much to the admirable experiments with fired gunpowder in closed vessels which were carried out in 1874 by Captain A. Noble, of Elswick, and Sir Frederick Abel; but our chief superiority is due to the practical results obtained with enlarged powder chambers and lengthened bores during a searching trial at the Royal Gun Factory in 1873; from these causes our ballistic knowledge has long been fuller and more complete than that of any of the Continental authorities; and it was really owing to this circumstance that England's guns held their ground as long as they did under the double disadvantage of being wrought iron muzzle loaders instead of steel breech loaders. The principle of chambering—that is, of enlarging that part of the bore which contains the explosive—depends upon a peculiarity in the action of powder charges which is not very generally known or understood. I will endeavor to make the facts clear to you. Supposing I fill a chamber which measures 3·15 in. in diameter and 18·6 in. in length with R. L. G.^{2} powder, at a density of 35·6 cubic inches per pound, as in the proof charge of the 12 pounder muzzle loading field gun, the pressure will be extremely capricious, varying from about 26 tons to 37½ tons per square inch; the velocities will vary also, but to nothing like the same extent. Next supposing I fill a chamber which measures 7 in. in diameter and 18·6 in. in length with 20 lb. 3 ozs. of R. L. G.^{2}, at the same density as before, as in the 7 in. muzzle loading gun, I shall get fairly regular pressures and velocities; the pressures will be about 22 tons only, varying about a ton above and below, although the densities of the charges are equal, and there is more than five times as much powder in the charge which gives the lower pressure.

This anomalous result arises from the shape of the chamber. It is found that long narrow chambers favor the development of "wave pressures," as they are called, in a surprising degree, and experience has clearly shown that to get the best effect out of the charge, the chamber should not be longer than from three to four times its diameter; with a powder which is slow in proportion to the size of the gun, it is generally safe to approach four diameters in length; but with a powder quick in proportion to the size of the gun, it is often dangerous to exceed three diameters in length. The cause appears to be that as soon as the charge is lighted the gas first evolved travels through the chamber from end to end with great rapidity, and sets up a dynamic action of a vibratory or wave character. But if it is asked why increasing the diameter of the chamber should mitigate and indeed remove this action, I have to confess frankly that I do not know. In the cases given the gas has just as far to travel, and to acquire momentum in, but it seems to lose the intensity of its rush from end to end when afforded increased space laterally. Many efforts have been made to overcome this difficulty, and to obtain satisfactory combustion in long narrow chambers by means of extensive air spacing, or by introducing central tubes of zinc and other substances; but the results have not been very promising, and in the Royal Gun Factory we have kept all our chambers short and thick, so as to consume the charges under the most favorable conditions. Hence it follows that if we wish to employ a charge which is too large to be contained in a portion of the bore four calibers in length, we must increase the diameter of the chamber. In practice, when designing a gun for a given charge, I start with the equation—$7\pi r^3 = C$, where r is the radius of the section of the chamber, and C is the cubic content required. This, of course, gives the dimensions of a chamber 3½ diameters long, which are subsequently adjusted as required.

There are also certain incidental advantages in shortening the cartridge by chambering; the length of travel of the projectile, and consequently its velocity at the muzzle, are increased. The shell has not to be rammed so far in, and the cartridge is more compact and serviceable. The disadvantage lies in the necessity for making the gun stronger, and therefore heavier, over the powder charge; in fact, the breech must be that due to the size of the chamber and not of the bore. Still, the ballistic advantages outweigh this, and as you see by the table A, the chambered guns beat all others in the energy per ton. There is one more point where chambering will probably prove of great service. The special duty of all very heavy guns, either for land or sea service, is to get their projectiles through armor. Of late years the armor question has undergone very great change. The guns easily mastered the wrought iron plate armor of the seventies, whether solid or in layers, but the use of steel, which has become general in the eighties, has checked the artillerist's victorious career.

Plates made either entirely of steel or of wrought iron faced with steel—the plates known as compound—are very difficult to get through or to smash if thoroughly well supported by firm backing. They break up the chilled iron shot, which splash harmlessly on the surface, while the steel shot fired at them usually break if too hard, or flatten out if too soft. We are trying to find the shot material which will prove most effective against this improved armor, and until this is accomplished we shall be unable to say with certainty what proportions should be given to the projectiles. The smashing or racking effect of a very heavy projectile of large diameter, striking with moderate velocity, may prove more effective than a lighter shot of smaller diameter and high velocity, or the reverse result may take place. We can adapt our chambered guns to suit either scheme. Since the caliber does not bear any fixed relation to the diameter of chamber, we can either enlarge the bore or reduce it by a thin lining, at pleasure, without interfering with the powder charge or its stronghold.

To recapitulate the principal points alluded to in this lecture, having come last among the great powers to steel breech loaders, we have been able to select the best points from the various systems worked out by others. The material is that proved admirable chiefly by German experi-

A.—Comparative Powers of Breech-loading Guns of 1881-1884.

Nature of gun.	Date.	Weight of gun.	Weight of charge.	Weight of projectile.	Ratio of $\frac{\sigma C}{a B}$	$\frac{W}{D^3}$	Muzzle velocity	Muzzle energy.	Perforation of iron at 1000 yd.	Energy per ton of gun.
		Tons.	Lbs.				Ft. sec.	Foot-tons.	Inches.	Ft.-Tns.
French, 34 c.m. (13·38in.)	1881	52	362	926	1·07	0·89	1968	24,868	22·9	478
French, 37 c.m. (14·56in.)	1884	71	546	1180	1·02	·38	1955	31,272	24·5	440
Krupp, 40 c.m. (15·75in.)	1881	71	485	1715	1·21	·44	1703	34,502	23·8	486
Krupp, 40 c.m. (15·75in.)	1884	119	615	1632	1·31	·42	2017	46,061	29·2	387
Elswick, 17in.	1882	100	772	2005	1·34	·41	1832	46,600	28·5	460
Elswick, 16·25in	1884	110	900	1800	1·69	·42	2020	50,924	30·5	513
Royal Gun Factories, 13·5in.	1884	63	625	1250	1·78	·51	2050	36,415	28·6	569
Royal Gun Factories, 9·2in. (wire)	1884	10	330	380	2·32	·50	2520	16,730	23·2	880
Elswick, 9·2in. (wire)	1884	18	200	380	1·85	·50	2200	12,759	20·0	709

* A section of the Elswick 43 ton gun partly made of wire may be seen in *The Engineer* of July 29, 1881.

ence; the system of breech loading is that of the French land service; some parts of our present construction have been tested in Germany and some in France, while we have been able to improve on both, and solidify the whole structure to a marked degree. Not being hampered by the necessity for utilizing old material, we have been able to devote all our energies to new guns of the best quality, instead of repairing and altering old guns of inferior type, as is being largely done all over the Continent. We have, moreover, greatly extended the ballistics of our guns, and have conferred on them unsurpassed power in proportion to their weight. It is true that in numbers we are behind, but having the best types, all that is required is money and a little more time. The money will no doubt be forthcoming at the good pleasure of the country, which must not hesitate to pay its war insurance. The time is more serious; a heavy gun cannot be made under about fifteen months, and the only way to economize in this respect is to put up sufficient plant to permit of a considerable number of heavy guns being under manufacture at the same time. This has been done to some extent, and the next two or three years will see us in a very different position as regards numbers. Still, there is much to be done, and I will conclude by earnestly representing that though sufficient confidence may not have been felt two or three years ago to justify the heavy outlay which was seen to be necessary to rapid re-armament, yet that now the time has arrived for the country to face the question seriously, to grant the money, and to push the manufacture.

In the discussion which followed, Admiral Hamilton and Admiral Boys spoke briefly, the latter asking for definite information as to the length of the life of a new type breech loading gun.

Mr. G. Rendel then questioned Col. Maitland's conclusions as to the proportions of a powder chamber. He noticed that Colonel Maitland apparently limited the length to 3½ diameters, to avoid wave pressures, but that he admitted the loss in increased diameter and strain on gun. Mr. Rendel had taken the case of the 43 ton gun, with 12 in. bore and 16 in. chamber, and had calculated that if the same capacity of chamber were obtained by simply lengthening the 12 in. bore, the gun's weight might be reduced from 43 to 36 tons—a great consideration in the navy. Colonel Maitland had said that in such a case the strain on the carriage would be increased. Mr. Rendel found that this would only be increased from 275 to 320 foot tons, which need involve little more than an increase in size of the hydraulic buffer. On the other hand, the gain in reduced diameter by having no enlarged chamber was very great; it helped to the same end as the abolition of trunnions, namely, the bringing of the two guns in a turret close together, so as to approach the condition of a double barreled gun. By this the couple with which the recoil of each gun acted with a tendency to rotate the turrets was decreased, and further, the whole turret may be decreased in diameter. He thought that wave pressures would not be developed with really slow burning powder. The 100 ton breech loading gun at Spezia had a chamber over five diameters long, yet it exhibited no wave pressures. Further, Mr. Rendel maintained that the advantages of reduced diameter were such that we ought to try all devices for igniting the charge, so as, for example, igniting it in several places.

Colonel Hope remarked that he was glad to find none of the wrong opinions of the official text-books of 1879 put forth by Colonel Maitland. Colonel Maitland had asked for an explanation of the wave pressure set up in long chambers. This Colonel Hope could supply. He (Colonel Hope) had dealt with the question practically, and had burnt charges 15 calibers long without wave pressures being generated. He had ignited charges at 140 places simultaneously. His shot moved before his charge was all ignited. Sir William Armstrong had, he considered, attempted something in this way when he lit his charge by means of a vent opposite to the front close to the projectile, but the result had been to blow out the breech of the gun. The fault we have constantly committed has been to treat the powder as an explosive, although we have long since learned that it is not an explosive. In fact, as regards the ignition of the charge, we have not advanced one step since the battle of Crecy. When a small portion of powder just below the vent is converted into gas it drives the remainder forward and compresses it, so that when it ignites in, say, half the space it originally occupied, it produces double the pressure contemplated. Thus a wave is set up that the gun cannot withstand.

Sir F. Bramwell objected that Colonel Hope had, indeed, given an explanation of wave pressure when absolute length is increased, but he had not explained the question raised by Colonel Maitland, which was one of the relative length and diameter. In the diagram shown were two charges of the same absolute length; the difference was in diameter. The gun with larger diameter had the longer projectile, and the greater resistance on each square inch of cross section, yet the pressure in the bore of smaller diameter was the greater. He confessed that he did not understand why the relation of length to diameter told in this way, and he had as yet heard no explanation of it.

Herr Kraftmeier spoke of the progress made with brown prismatic—*i. e.*, cocoa—powder, especially in an effort which was being made to suit it to field guns. The prisms were 1 in. in diameter and ¾ in. in height. Experiments were not yet concluded. He trusted that when the money referred to by the lecturer was voted, that powder might receive its share of it.

Captain Palliser observed that Colonel Maitland's commendation of a system of construction consisting of steel hoops of comparatively moderate dimensions, was very important in its application to the case of such arsenals as might be established by colonies. He—Captain Palliser—had just been consulted with regard to an arsenal to be established at Quebec.

SHERATON DRAWING ROOM FURNITURE.

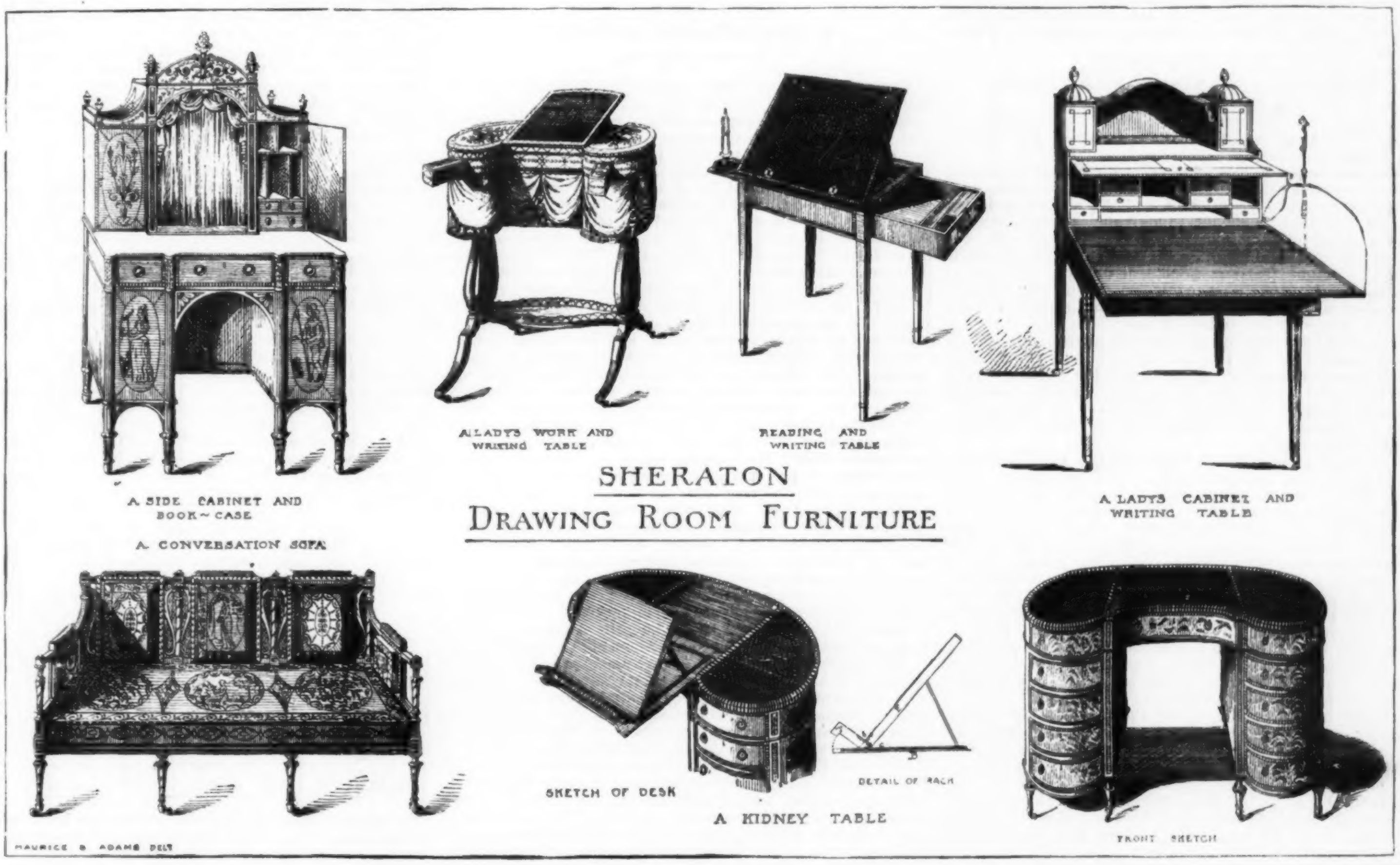
THESE drawings are all taken from Sheraton's own details, and the pieces of furniture thus shown furnish a very good representative selection of the designs and style which made this well known maker's work so justly celebrated. The specimens are all of a finished and delicate character, and are suited to the requirements of the drawing room and "my lady's boudoir," although in no case has these fancy or elegance been permitted to interfere with the utility of the article or the objects for which it was made. Indeed, one of the special charms of Sheraton's furniture, generally speaking, is very largely due to the usefulness and simple proportions of his designs, strongly made as they are, and nearly always free of mere ornament introduced only for ornament sake.

The Kidney Table, so useful for the varied purposes of a library or the lighter occupations of the withdrawing room, obtains its name, Sheraton tells us, "on account of its resemblance to that intestine part of animals so called." The drawers in two nests, one on either hand of the user, are all real, having fronts strung and cross banded with the grain of mahogany laid up and down. The pilasters or uprights are plainly treated in the same fashion with panels of cross-banding, and the feet of the legs are turned and supported on casters. The ends are paneled with veneer of mahogany, and so is the back. Being intended usually to stand in a bay window or in the center of the room, the face of the table on every side is of an equally finished character.

The reading desk contrived in the center of the table top deserves a descriptive reference, and we have added a perspective sketch of this part with a diagram of the rack. B is the profile of the frame, which slides out with a groove in its edge, shown by the black line. A metal tongue fixed in the slide works in this groove to steady the rack piece and stop the drawer from pulling out too far. F is the desk raised by a horse, and A is the fore part of the desk top, which rises and forms a book-rest or stop. J is a "tumbler" hinge let in flush with the top, and hid by the leather cover. C is a common cut hinge let in the edge of the desk, F, and upon the frame, B, so that when F falls to B, A does the same, and the slide becomes part of the table top proper. The length of the table is 4 ft., its width 2 ft., and its height 2 ft. 8 in.

The lady's cabinet and writing table, which figures above the last named piece, is a singularly nice specimen of elegant design. It is for writing on and to hold a few small books of constant reference at the back, the curved top insuring a tidy appearance, as it is unsuited to the storage of papers and other odd things so often piled up when a straight top affords a tempting space for such a purpose. The two little towers or cupboards, surmounted by small domes at the sides, are fitted as stationary cabinets or drawers, and the lower stage of the upper part is occupied by letter holes and drawers; its lifting front falling down from F to G, and locks into the flap of the folding top, which turns up like a card table, and which, when it is open, obtains a support by the drawer which pulls out from the table top frame. The reading and writing table, drawn in facsimile to Sheraton's own sketch, with his quaint perspective, is another plain example similar in style to the one just described. A candle slide bracket draws out at the end, and a fitted stationery drawer pulls out the whole depth of the table's length at the other.

The top rises for a reading desk, with an adjustable horse-rack behind. The book rest is contrived by fixing in a pair of pin catches, screwed to a lath moulding into the brass flush eyes provided, as shown in the table top, which rises as stated. The work table, with drapery flouncing at the sides to hide the workbag, is fitted with a somewhat similar reading or writing desk. Small pen and pencil drawers pull out at the sides, and a useful lower shelf with a fretwork verge occupies the central stage below. The sofa is of 1793 date, and was, therefore, made two years after Sheraton's "Drawing Book" was published. It is a typical specimen, both handsome and convenient, as a side seat or conversation sofa. The cabinet bookcase is more elaborate in design than the other pieces, and has several useful recesses, drawers, and cupboards both in the upper and lower halves.—*The Building News.*



SHERATON DRAWING ROOM FURNITURE

RETOUCHING GELATINE NEGATIVES.

MANY photographers varnish their dry plate negatives, and then retouch them just as they were in the habit of retouching their collodion negatives, while others retouch directly upon the gelatine film; but it not unfrequently happens that the film is not in a condition to readily take the pencil markings, and in such a case the following mixture is useful:

Ordinary oil of turpentine	100 parts.
Common resin	2 "
Venice turpentine	4 "

A little is applied to the film with the tip of the finger, and rubbed until dry.

Some years ago, Carroll recommended the use of a solution made by dissolving twelve grains of tannin, ten grains of gum, and one grain of salicylic acid in one ounce of water; this solution being distributed over the surface of the plate by means of a glass rod, and the excess drained off, after which the plate is allowed to dry.

An aqueous solution used in an analogous way is recommended by Re, of Jeletz, the fixed and washed plate being allowed to remain for a quarter of an hour in a solution of acetate of aluminum, after which it is allowed to drain and dry; and this mode of treatment can be repeated if the surface is not rendered sufficiently matte by the first operation. Negatives which have been properly treated with acetate of aluminum are as easy to retouch as gummed collodion negatives.

The acetate of aluminum solution for the above use can be readily prepared by dissolving one part alum in ten parts of hot water, and adding sufficient ammonia to throw down all the alumina, or sufficient ammonia to make the mixture smell of this reagent after a thorough stirring. The gelatinous precipitate of alumina is now collected on a cloth, and well washed; after which it is dissolved in a mixture of

two parts of glacial acetic acid and one part of water. The acetic acid must be thoroughly saturated with alumina, and one can only be sure of this after it has remained for two or three days in contact with a portion of the precipitate. The solution of acetate of alumina should be filtered before use, and it must be kept in a well stoppered bottle.—*Photo. News.*

PHOTOGRAPHING A PISTOL BALL AND SOUND WAVES.

THERE is nothing absolutely novel in the photographing of a cannon ball during its flight, but such an experiment is ordinarily regarded as a mere curiosity.

Professor E. Mach, of the Physical Laboratory in Prague, has recently secured some remarkable photographs of a bullet during its flight, and has also obtained camera representations of other extremely transitory phenomena.

No mechanical exposing apparatus of the drop or spring-shutter type was used, but the required instantaneous exposure was secured by illuminating the object with the light of the electric spark. The ball was fired in the direction of a battery of Leyden jars, and in such a manner that it itself made the contact which produced the electric discharge serving to illuminate the projectile. In this way a far shorter exposure was realized than one could hope to attain by any kind of mechanical shutter. Professor Mach's experiments were made in a darkened room, and the objective remained uncovered during the whole of the time, but of course the plate only received the luminous impression of the instant when the ball was illuminated by the electric discharge.

The negatives are extremely small and transparent; but with a magnifying glass it is easy to distinguish the clear and sharp image of the projectile.

Not only has Professor Mach photographed the bullet in its course, but also the air streams which one may see over a Bunsen burner when bright sunlight is allowed to play on it; and, what is more surprising still, he has actually secured camera representations of waves of sound, these last being made visible by Toepler's method, in which advantage is taken of the irregular refraction of light by the air set in vibration by sound. It is to be hoped that by taking advantage of the intense and instantaneous light of the electric discharge, many physical phenomena may be registered by the camera; and we shall look forward with interest for further details of Professor Mach's experiments.—*Photo. News.*

BLEACHING AGENTS OF THE FUTURE.

By E. DWIGHT KENDALL.

"*Nothing seems so difficult as the invention of to-morrow, nor so easy as the invention of to-day.*"

The best means of bleaching are with Nature's oxidizing agents, peroxide of hydrogen and ozone. The method of bleaching by the co-operation of sunlight, air, and moisture, the practice of which extends to most ancient times, depends on the formation of peroxide of hydrogen, from water and oxygen, under the influence of the sunlight. The peroxide [H_2O_2] contains two equivalents of oxygen, or twice as much as water [H_2O], one equivalent being slightly held, and therefore in active condition. The natural circumstances necessary to produce it have been studied; those which limit its production are not well understood. Water being capable of holding in solution only a comparatively minute quantity of oxygen, and the peroxide being formed by the combination of the water with its contained oxygen, the exhaustion of the latter must end the production of peroxide, except as oxygen is thereafter slowly absorbed from the air.

The action of peroxide on organic matter, as in bleaching, involves its own decomposition; it becomes water again, the oxygen given off uniting with the carbon and hydrogen of the organic matter to form carbon dioxide and water; if there be nitrogen in the organic body, ammonia also is produced. At present, peroxide of hydrogen in a form available for bleaching purposes is too costly for general use; its application is limited to fine goods. In its most concentrated state the peroxide has a spec. grav. of 1·45; it is without odor and colorless; it loses oxygen by slight elevation of temperature, but is comparatively stable when diluted with water. It bleaches without having, at any time, an acid character. The ordinary chemical process for obtaining it is not simple, but is susceptible of improvement; a new method, however, is likely to be followed.

Possibly a bleaching agent of the future is the natural purifier of the atmosphere, ozone, a body which has been the subject of much discussion, but whose chemical character and place in nature have been made known by the experimental researches of Schonbien, the discoverer, Williamson, Osann, De la Rive, Faraday, Marignac, Fremy, Becquerel, Horsford, Meidinger, Andrews, Hozeau, Van der Willigen, Cloez, De Lucca, Beauchamp, H. Clausson, Daubeny, Soret, Tommasi, and others.*

No method has yet been devised for producing ozone cheaply for bleaching purposes, although it has lately been employed to whiten sugar. It has also been used for the defuselation of liquors (*i. e.*, the oxidation of the amyl alcohol and grain oils) and in the manufacture of vinegar. In limited quantities it may be obtained in various ways, for example, by the electrolysis of certain acid and saline solutions; by disruptive and, preferably, by silent discharges of frictional electricity through dry oxygen or air; by electro-inductive action; by oxidation of phosphorus in moist air or in moist heated or rarefied oxygen, or in oxygen with an admixture of hydrogen or carbon dioxide; by oxidation of certain essential oils; by treating potassium permanganate or barium dioxide, in fragments, with monohydrated sulphuric acid, etc.

The causes of ozone in the atmosphere are only partially known; it is to some extent the result of electric conditions. It is not generated by the action of sunlight on moist air. From whatever source obtained, it exhibits the same characteristics.† It is probably the most powerful oxidizing agent known. Its bleaching power is remarkable, a small quantity sufficing to discharge the color of an exceedingly large quantity of indigo disulphonic acid. It also bleaches several rosaniline and methylrosaline colors; also corallin, iodine green, extracts of dyewoods, and, it is said, even Turkey-red. It readily attacks metals and oxidizes even polished silver; it decomposes salts of manganese monoxide, with separation of hydrated dioxide; it decomposes caoutchouc rapidly; it precipitates iodine like chlorine; it combines with ethene and destroys hydrogen monosulphide and hydrogen selenide, with formation of water and separation of sulphur and selenium; it converts sulphurous acid to sulphuric acid and thallious oxide to thallic oxide; it precipitates peroxide of lead from plumbic compounds; changes yellow potassium ferrocyanide to red ferricyanide, sulphides to sulphates, and in presence of alkalies and air forms nitrates; it liberates chlorine from hydrochloric acid (which indicates that it is a more energetic agent than chlorine); it causes the explosion of potassium picrate, nitroglycerine, and iodide and chloride of nitrogen, etc. Finally it destroys ligneous and albuminous substances; violently attacks the mucous membrane, exciting catarrhal inflammation, and, in excess, kills animals and plants.

What is ozone? It is oxygen having the density 24, the density of ordinary oxygen being 16; Soret proved this by experiments based on Graham's law, "that the velocity of diffusion of a gas is inversely as the square root of its density." Heat decomposes ozone, reducing it to *ordinary oxygen and increasing its volume by one-half*. Chemists have agreed that the active character of ozone is due to its atomic structure; the molecule of oxygen being composed of two atoms of oxygen (O=O), that of ozone consists of three, $\left\{\begin{matrix} O-O \\ \diagdown O \diagup \end{matrix}\right\}$ an allotropic condition easily disturbed, one unsatisfied atom being always ready to enter into a new combination. Potassium iodide absorbs this atom from ozone, reducing it to *ordinary oxygen, the volume of which remains the same as that of the ozone, but the density changes from 24 to 16.*

Ozone is regarded as the natural disinfectant or purifier of the air we breathe. From countless sources, effluvia poisonous to animal life, emanations from putridity, invisible miasmata and germs of contagion are discharged into the atmosphere; the active oxygen of ozone destroys these bodies, converting them into watery vapor and harmless gases. This is believed to be the office of ozone. Why may not peroxide of hydrogen, having like characteristics, have similar functions in the vast seas swarming with living creatures, whose existence requires pure oxygen and depends on the balance of nature? Ozone is gazeous and but slightly soluble in water; hydrogen dioxide is incapable of assuming the gaseous form, but is perfectly miscible with water, in which and of which it is formed; may it not be a scavenger of the sea!—*Textile Colorist.*

*The writer investigated the nature of ozone, and published matter relating thereto in 1848 49.

† The purpose of this communication does not require reference to the electro-chemical theories of Prof. Odling and others, respecting ozone and antozone.

PYROXYLIN—GUN COTTON.*

By GUSTAVUS PILE.

Query: In making soluble gun cotton, what strength of nitric acid will yield the best results?

Under the general term gun cotton, there are included several varieties differing somewhat from each other in chemical composition and physical properties. By the action of nitric acid on cotton or cellulose, a number of equivalents of hydrogen are displaced by an equal number of equivalents of nitric oxide, which number may be altered by operating with different strengths and proportions of nitric and sulphuric acids, producing different forms of gun cotton, according to the amount of substitution. The variety which contains the greatest number of equivalents of nitric oxide is the most explosive, and is known as detonating cotton; it is, however, insoluble in ether and alcohol, and useless in pharmacy. As the quantity of nitric oxide is reduced, the products will be found less explosive, and at the same time more soluble, until a variety is reached containing so small an amount of nitrogen as to be but partially soluble, losing the explosive quality; merely burning instead, and leaving behind an ash. In the manufacture of any one kind, there will always be found present some of the other forms, which prove a source of trouble when preparing the particular variety best suited for making collodion; for when those forms which are but sparingly soluble in ether are present to any great extent, the resultant cotton will be very inferior or altogether useless. Our object, therefore, is to determine, if possible, what particular proportion and strength of acids will be required to produce the form of gun cotton that will be readily soluble and have as small an amount as possible of contamination with other varieties. In seeking to solve this question, I have made a great many experiments, using nitric acid of varying strengths, from 1·380 up as high as 1·450 sp. gr. I have added the sulphuric acid in large and small proportions; and following the suggestions of Mr. Charles H. Mitchell, whose paper appears in *The American Journal of Pharmacy*, 1872, I substituted various strengths of nitrous in place of the nitric acid, and in addition I made a number of experiments with having the mixed acids at different temperatures at the time of immersing the cotton, ranging all the way from 60° to 140° F. (15·5° to 60° C.), and in one instance continuously increasing the heat until 190° F. (87·7° C.) had been attained, when every trace of fiber had broken down. As a result of my labor, I do not find it an easy matter to state just what is the best formula of all that I tried, for I have obtained very good products when using the weakest as well as the strongest acids; still I am not willing to acknowledge that I learned nothing for my pains, and, taking all things into consideration, I believe that by using nitric acid of 1·450 specific gravity a very good cotton can be obtained with much less liability of a failure than where the weaker acids are employed; in fact, I met with little difficulty, and secured a good crop each time I operated with it. Cotton prepared from this acid will be found quite explosive, leaving no ash. It dissolves in the mixture of ether and alcohol, as directed in the Pharmacopœia, making a solution of such great viscidity, however, that at least twice the amount of liquid there stated is required to make a collodion of a proper fluidity. For these reasons, therefore, I offer the following formula, and believe it to be the best of all my efforts toward a solution of the query:

Take of nitric acid 1·450 sp. gr. and sulphuric acid 1·835 sp. gr. equal volumes each, and mix with a glass rod in an evaporating dish; cover this with a pane of glass and set aside till the temperature, which will be about 120° F. (48·8° C.) at the time of mixing, has fallen to 95° (35° C.) or 100° (37·7° C.). Then add as much absorbent cotton (not in thick wads, but well separated) as can be thoroughly saturated, and allow it to stand for ten hours longer. The acids are then to be poured off and kept for future use. Throw the cotton into a large vessel of water and wash well, a small amount of sodium carbonate being added to the last of the wash water. Transfer to a glass funnel or percolator, and allow a stream of water to pass through in order to remove every trace of adhering acid; after which, press out as much water as possible, pick it somewhat apart, and place it on several thicknesses of paper in a proper place to dry. The amount of acid may be taken by weight instead of volume, by using them in the proportion of 10 parts of the nitric acid and 12 of sulphuric acid, the quantities being relatively the same in either case. When absorbent cotton is used, the amount ordered in the officinal formula appears to be too great, and I have had to be satisfied with about three-fourths as much; but if cotton yarn be used, which I have found to answer very well, nearly twice the weight can easily be incorporated. Samples of gun cotton and collodion, illustrating some of the peculiarities noticed, are presented for your inspection.—*Pharmacist.*

* A paper read at the Pennsylvania Pharmaceutical Association meeting.

LIQUEFACTION OF GASES.

THE FREEZING OF ETHER AND ALCOHOL.

ON the evening, of June 13, Professor Dewar gave an experimental lecture at the Royal Institution on *The Liquefaction of Gases*. Mr. Warren de la Rue presided. Among those present were Professor and Mrs. Edward Frankland, Sir William Bowman, Professor Tyandall, Lord Ranelagh, Professor Hughes, Miss Ottley, Colonel Pinney, Dr. Topham, Dr. Maudslay, Miss Emmett, Dr. Macpherson, Earl Percy, Captain Baillie, Dr. Tidy, Mrs. Ralli, Rear-Admiral De Kanzow, Mr. Dent, Mr. and Mrs. William Crookes, and Dr., Mrs., and Miss Edmunds.

Professor Dewar had arranged in the theater a variety of pieces of apparatus for the production of extreme cold far below that obtainable by means of a solution of solid carbonic acid in ether. He first, however, drew attention to an iron vessel containing carbonic acid liquefied by pressure; when the carbonic acid was permitted to escape by turning a stopcock it chilled itself by expansion, and became condensed as carbonic acid snow, which could be handled with impunity despite its intense coldness, because it does not touch the hand, a layer of its vapor being always between the hand and the snow. This snow floated on the top of cold water, but when he compressed it into carbonic acid ice by a force of between one and two tons to the square inch, it sank in water, and gave off bubbles of gas freely. The ice could not be so easily handled as the snow. A solution of solid carbonic acid in ether gives a temperature of —80° Centigrade, which is the boiling point of carbonic acid; at this temperature mercury is frozen rapidly. By placing the mixture under the air-pump, to increase the evaporation, he obtained a temperature of —110° C., and he stated that —115° C. is about the lowest temperature obtainable by means of solid carbonic acid, which was the lowest temperature Faraday could obtain in the state of knowledge in his day.

In the lower temperatures now obtainable, he said, an air thermometer is useless for measurement, for air itself can now be liquefied by cold and pressure. The thermometer he used was, he stated, both simple and effective. It consisted of long, thin bands of copper and iron soldered together at the ends so as to form a thermopile. The soldered junctions of one end of the pile were kept at a constant temperature by being placed in water containing melting ice; the other end of the pile was put in the liquid the temperature of which had to be ascertained. The current from the pile passed through the coils of a reflecting galvanometer, which threw a vertical line of light upon a long white paper scale stretching all across the back of the theater of the Royal Institution. The movements of this line of light along the scale indicated the temperature obtained in each experiment.

Liquid ethylene was the substance employed to produce the intense cold afterward employed by the lecturer. About five pounds weight of it, under a pressure of 100 atmospheres, was stored in an iron bottle. His assistants had been about a fortnight making this quantity. They made it a little at a time and then put it in the large bottle, which stood in a vessel surrounded with ice and salt to keep it cold; for ethylene cannot exist in the liquid form above the temperature 10° C. Ethylene is the chief illuminating constituent of common coal gas, and burns in air with a smoky flame. The boiling point of ethylene is —103° C., and by placing it under the air-pump a cold of —145° C. or —150° C. can be obtained. The following are the temperatures at which the gases named become liquid:

BOILING POINTS BELOW THE FREEZING POINT OF WATER.

	Boiling Point below F. P. of Water.	Boiling Point in Vacuum.
	Degrees Centigrade.	Degrees Centigrade.
Carbonic acid	—80	—116
Nitrous oxide.....	—90	....
Ethylene....... .	—103	—142
Oxygen..........	—184	—198
Nitrogen.........	—198·1	....
Air...............	—192·2	....
Carbonic oxide....	—193	....

The greatest cold yet obtained by man has been reached by two Russian physicists, Wroblewski and Olszewski, who by the use of liquid oxygen produced a temperature of —200° C. Hydrogen has been condensed into a mobile, colorless fluid; and although, chemically, hydrogen possesses the properties of a metal, in its liquid state it presents no appearance of metallic reflection.

The experiment of most interest to photographers was that in which Professor Dewar froze absolute alcohol. This was done by allowing some liquid ethylene to flow through a brass tube surrounded by solid carbonic acid and ether. When thus cooled it was passed into a large test tube, in the middle of which was placed a glass tube with a flattened bulb at the end, the bulb being full of absolute alcohol. The evaporation of the ethylene was then accelerated by the use of the air-pump, and the alcohol was frozen into a mass as clear and transparent as crystal. The tube containing it was turned bottom upward, and as it melted it assumed exactly the consistence of glycerine, flowing in a sluggish way down the sides of the tube. Ether requires less cold than alcohol to freeze it, and in several of the experiments ether ice formed on the sides of the glass vessels; but Professor Dewar said nothing about its peculiarities, except that it interfered with the view of what was taking place inside the vessels. The warm air of the theater was constantly condensing as snow or hoar frost on some of the vessels used in the experiments, and the chief difficulties of the lecture were the projecting of the experiments on the screen by the electric light so that all present might see what was taking place.

During the evening Professor Dewar momentarily liquefied oxygen. The lecturer also proved that ozone is a blue gas, which at a very low temperature dissolves in bisulphide of carbon, forming a blue liquid. As the temperature rises, the ozone oxidizes the bisulphide of carbon with explosive violence. He said that there was no reason why some of these condensed substances should not be utilized for prac-

tical purposes—indeed, that there was no doubt they would be so utilized.

In the course of the lecture Professor Dewar called attention to the following table, the first column of which gives the temperatures at which the various substances are liquefied:

RANGES OF PHYSICAL CONDITIONS.

	Point of Fusion.	Range of Liquid.	Range of Solid.
	Deg. C.	Deg. C.	Deg. C.
Water	0	370	273
Cyanogen	—34	158	239
Carbonic acid	—65	97	208
Sulphurous acid	—75	230	98
Ammonia	—75	204	98
Hydric sulphide	—85·5	186	187·5
Nitrous oxide	—100	135	173
Chlorine	—102	250	171
Carbon sulphide	—110	386	163
Hydrochloric acid	—112·5	163	160
Phosphorous chloride	—114	400	159
Ether	—117·4	413	155
Alcohol	—130	365	143
Amyl alcohol	—134	440	139

HOW THE EARTH IS WEIGHED.

PROBABLY of all the marvels of astronomy there is not one more astonishing, or one which would seem more impracticable to the ordinary reader, than that of determining the weights of the earth and other celestial bodies, and expressing such weights in tons or pounds avoirdupois.

Ordinarily, when speaking of the weight of a body, we refer to the force of the earth's gravity tending to resist the action of raising or lifting, and we are accustomed to express that force in terms of some unit. That is, we term the force of gravity acting on some substance of known bulk "one," and we express other weights by comparison in multiple integer, or fractional parts of that unit. We are all familiar with the simple method of making such comparisons by placing bodies of known weight on one end of a self-poising lever until they counterbalance the substance, the weight of which we wish to determine, in the other.

Perhaps Atlas may by this time have formed a tolerably correct estimate of the weight of our globe, but ordinary mortals must proceed in a much more roundabout and intricate method in order to arrive at a satisfactory computation. At the outset the problem must be resolved into a statement such as this: It is required to substitute for the earth a solid and uniform globe, so as still to preserve the same weight of bodies on its surface, and not to diminish the attractive force of the sun and planets. Of what material must such a globe be composed?

It was the discovery of the law of gravitation by Newton, and the subsequent evolution of his theory of celestial mechanism, that naturally first gave rise to the question of the earth's weight; and though without the means of experimental investigation, the philosopher shrewdly computed from theoretical considerations the density of the earth to be between five and six times that of water *—a calculation which as we shall see was almost correctly divined.

Since the time of Newton many remarkable experiments have been made by eminent observers. The principle upon which all such experiments have invariably been conducted is to ascertain the force of attraction exercised by certain bodies of known dimensions, and then, the size of the earth and its attractive force being known, to work out the problem in the following manner: As the size of the earth is to that of the body tested, so would be its attractive power if the specific densities were the same, attraction being proportional to density.

Between 1774 and 1776 Dr. Maskelyne, the Astronomer Royal, experimented on the mountain of Schehallion, in Perthshire, with a plumb-line, with the view to ascertain the attraction exercised by a large mountain in deflecting a plummet from the vertical line, as it is evident, if matter attract matter, a mountain contiguous to a plumb-line or spirit-level will, in a slight degree, alter the position of the former or the surface of the latter. But Maskelyne's experiments were not scientifically satisfactory.

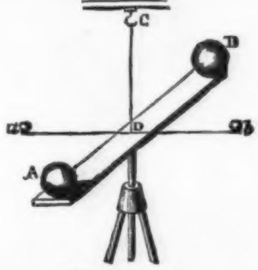
Henry Cavendish, the "Newton of Chemistry," made an important suggestion for another mode of investigation, which Mr. Francis Baily subsequently reinvestigated and worked out in a series of experiments extending over several years, resulting in a determination of the exact weight or density of the earth. We will now briefly describe Baily's *modus operandi*, for his method is certainly the most precise of any yet attempted.

The apparatus used by Mr. Baily may be represented roughly as in the figure. Two balls, *a* and *b*, about two inches in diameter, were placed at each end of a torsion pendulum, 76 inches long, suspended by a wire, C D. Upon a revolving frame were then placed two balls, A and B, 12 inches in diameter. Having first accurately determined the position of the two small balls (or the principal attracted substances), *a* and *b*, by means of telescopic observation, the two larger balls, A and B, were slowly approached by means of the revolving frame so carefully that they could produce no effect on the small ones except through *the force of their attraction*. Great precaution was taken to insure against the effect of electricity or radiation by means of suitable insulation, in noting the actual position of the pendulum, etc. On their approach the small balls deviated by a minute quantity, and this quantity was carefully observed. The large balls were then reversed by the turning frame, and the deviating effect again noted. Baily made upward of 2,000 experiments, the amounts of deviation or deflection being in each case noted. This element having been ascertained, it is no difficult matter to compute what *dead pull* the large balls must have given the small ones to produce such deviation. If lead balls twelve inches in diameter exert such a force, what would they exert were they as large as the earth?

Now the force of gravity being known, we may compare that force with the attractive force of lead; the density of the latter being known, we can thus ascertain the former. The mean of Baily's experiments gives the earth's density as 5·67, or more than 5½ times that of water. Cavendish, with his less elaborate and perfect apparatus, obtained 5·48 as a result, and Mr. Reich 5·44.

This experiment of Mr. Baily, or rather the Cavendish experiment, as it is called, besides its intrinsic value, may be regarded with additional interest by reason of the demonstration it affords of Newton's celebrated dictum—that every particle in the universe attracts every other with a force inversely proportional to their distance asunder. It is this power which moves the solar system and maintains conditions of equilibrium by which the celestial constitution is governed and bound together in one bond of union. There is yet a third method which has been proposed for determining the earth's density, which was experimentally investigated in 1854 by Mr. (now Sir George) Airy, who compared the motions of two invariable pendulums, one at the top and the other at the bottom of the Harton Colliery in Cumberland, 1260 feet under the ground.

The pendulums were arranged in the same vertical line, and their coincidences with the pendulums of two clocks were simultaneously observed, the relative rates of the clocks being determined by galvanic apparatus. After each series of experiments the pendulums were interchanged. Mr. Airy observed that the pendulums differed in rate 2¼ seconds per day. This shows that gravity for that depth was increased by the 1·19190 part. The resulting mean density of the earth deduced from the experiments was 6·565, or between six and seven times that of water. But although great precautions were taken in the matter of applying corrections, yet Mr. Airy considered that the natural environment of the



Baily's Apparatus.

district—such as the depth of the Tyne oasin, the specific gravity of the rocks in the Harton mines, and the like—was not duly taken into account. Hence it is that the result of the Cavendish experiment, as performed by Baily, must be regarded as the most satisfactory. Indeed, there are obvious difficulties in the way of arriving at a correct result in the case of Maskelyne's and Airy's experiments. In the former experiment it was of course necessary for accuracy to know the precise mass of the mountain, which in reality could only be ascertained approximately; and in the latter, circumstances similar to those mentioned above must always, to a greater or less extent, cause an incompleteness in the result obtained.

The density of the earth, then, may be said to be 5·67 (more than 5½) times that of water. In other words, the earth's weight is 5,842,000,000,000,000 (5,842 billions) of tons, although this long aray of ciphers conveys but little idea of the concrete significance of this weight.—*Science Monthly.*

* "Verisimile est quod copia materiæ totius in terra quasi *quintuplo* vel *sextuplo* major sit quam si tota ex aqua constaret."—*Principia*, III., 10.

THE EXTINCT LAKES OF THE GREAT BASIN.

THE Great Basin of North America presents the most singular contrasts of scenery to the regions that surround it. East of it rise the dark pine-covered heights of the Rocky Mountain system, with the high, bare, grassy prairies beyond them. To the west tower the more serrated scarps of the Sierra Nevada, with the steep Pacific slope on the other side. The traveler who enters the Basin, and passes beyond the marginal tracts where, with the aid of water from the neighboring mountains, human industry has made the desert to blossom as the rose, soon finds himself in an arid climate and an almost lifeless desert. The rains that fall on the encircling mountains feed some streams that pour their waters into the Basin, but out of it no stream emerges. All the water is evaporated; and it would seem that at present even more is evaporated than is received, and that consequently the various lakes are diminishing. The great Salt Lake is conspicuously less than it was a few years ago. Even within the short time that this remarkable region has been known, distinct oscillations in the level of the lake have been recorded. There are evidently cycles of greater and less precipitation, and consequently of higher and lower levels in the lakes of the Basin, though we are not yet in possession of sufficient data to estimate the extent and recurrence of these fluctuations.

It is now well known that oscillations of the most gigantic kind have taken place during past time in the level and condition of the waters of the Great Basin. The terraces of the Great Salt Lake afford striking evidence that this vast sheet of water was once somewhere about 1,000 feet higher in level, and had then an outflow by a northern pass into the lava deserts through which the canons of the Snake River and its tributaries wind their way toward the Pacific. Mr. Clarence King, Mr. Gilbert, and their associates in the survey of the 40th parallel threw a flood of light upon the early history of the lake and the climatic changes of which its deposits have preserved a record. They showed that the present Great Salt Lake is only one of several shrunken sheets of water, the former areas of which can still be accurately traced by the terraces they have left along their ancient margins. To one of the largest of these vanished lakes the name of the French explorer Lahontan has been given. The geologists of the 40th Parallel Survey were able to portray its outlines on a map, and to offer material for a comparison between it and the former still larger reservoir of which the present Great Salt Lake is only a relic. The United States Geological Survey has since begun the more detailed investigation of the region, so that ere long we shall be in possession of data for a better solution of some of the many problems which the phenomena of the Great Basin present. In the mean time Mr. J. C. Russell, who has been intrusted with this work, has written an interesting and suggestive preliminary report of his labors.

The average rainfall of the area of the Great Basin is probably not more than 12 or 15 inches. In the more desert tracts it may not exceed 4 inches, though in the valleys on the borders of the Basin it may rise to 20 or 30 inches. The rain falls chiefly in autumn and winter, consequently many of the streams only flow during the rainy season, and for most of the year present dry channels. Even of the perennial water-courses, the larger part of their discharge is crowded into a brief space toward the end of the rainy season. Most of the streams diminish in volume as they descend into the valleys, and many of them disappear altogether as they wander across the blazing, thirsty desert. Loaded with sediment and more or less bitter with saline and alkaline solutions, they do little to redeem the lifelessness of these wastes.

Over the lower parts of the surface of the Basin are scattered numerous sheets of water. Where these have an outflow to lower levels they are fresh, as in the examples of Bear Lake, Utah Lake, and Tahoe Lake. But the great majority have no outflow. Some of them are merely temporary sheets of shallow water, appearing after a stormy night, and vanishing again beneath the next noonday sun, or gathering during the rainy season, and disappearing in summer. Yet in some cases these transient lakes cover an area of 100 square miles or more. When they dry up, they leave behind them hard, smooth plains of grayish mud, that crack up under the burning sun, and then look like a broken mosaic of marble. Of the permanent lakes the largest is the Great Salt Lake. It is also by much the most saline. Though all of them are more of less charged with alkaline and saline solutions, the percentage of these impurities is in some cases not so great as to prevent the water from being drunk by animals, or even on an emergency by man himself. Nothing in the physics of the Basin is more remarkable than the great diversity in the amount and nature of the mineral substances in solution in the lakes.

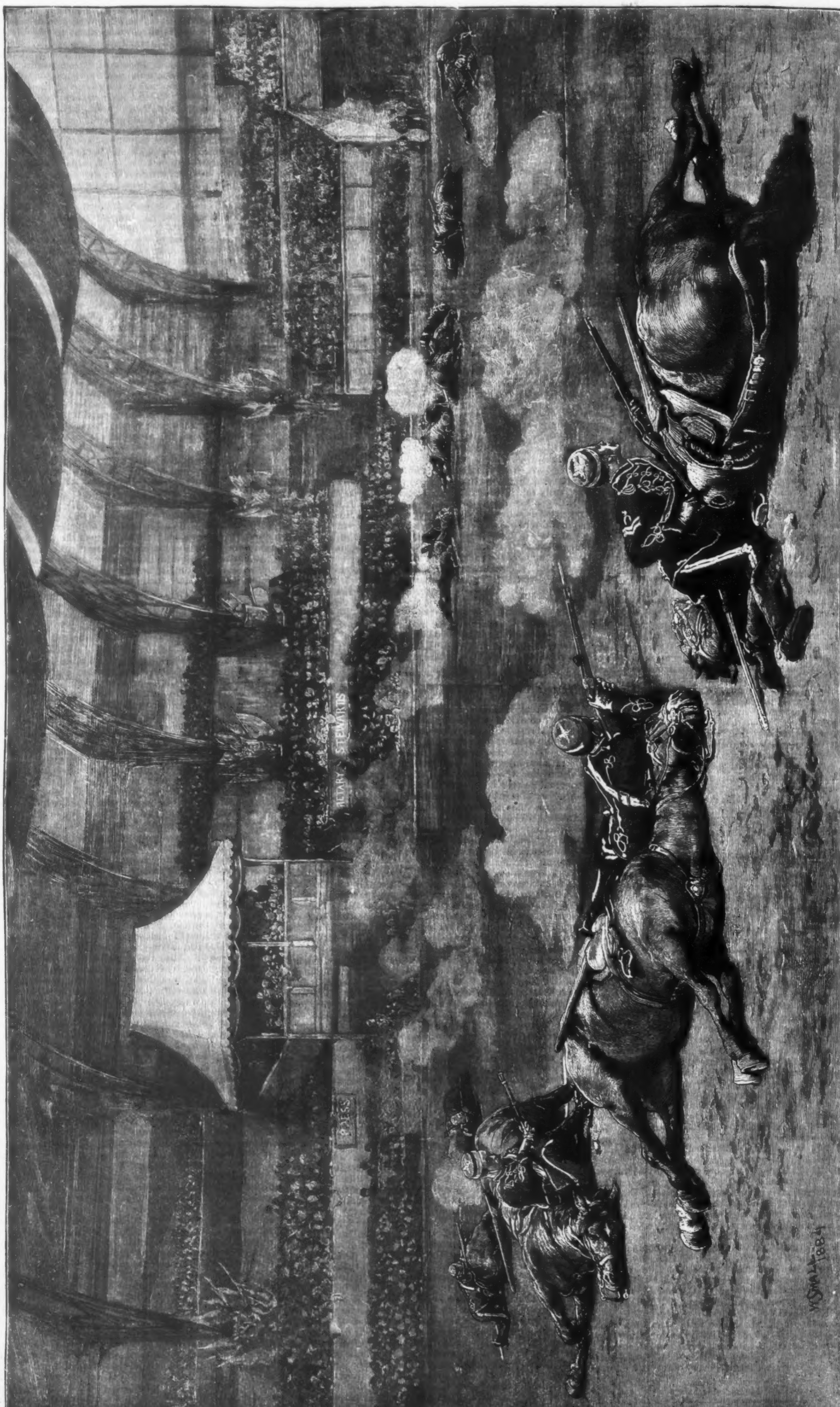
The vanished sheet of water, or "fossil lake," as the American surveyors call it, known as Lake Lahontan, lay chiefly in the northwest part of Nevada, but extended also into California. In outline it was exceptionally irregular, being composed of a number of almost detached strips and basins connected by narrow straits, and sometimes separated only by narrow ridges. It inclosed a rugged, mountainous island 126 miles long from north to south and 50 miles broad, which contained two lakes, neither of them apparently overflowing into the main lake. The Central Pacific Railroad passes for 165 miles through the dried-up bed of Lake Lahontan. From the windows of the car one can look out upon the ancient clay floor of the lake and mark the marginal terraces winding with almost artificial precision along the bases of the hills. The larger basins, which were formerly united into one continuous sheet of water, still hold lakes, all of which are more or less saline and alkaline, but they are far from being such concentrated brines as might be expected were they due to the progressive evaporation of the large original lake.

In tracing back the history of this interesting topography we are first brought face to face with the fact that the area of the Great Basin has within recent geological times been subject to powerful and long continued subterranean movements. In numerous cases, rocks have been fractured and displaced to an extent of 4,000 or 5,000 feet. So recent are some of the fractures that they actually cut through the alluvial cones that stream out from the base of the mountains, and in numerous instances displace the terraces of the old lake to the extent of 50 or 60 or sometimes even 100 feet. There seems no reason to dispute the conclusion to which Mr. Russell and his colleagues have come, that the movements are actually still in progress, and that the constant occurrence of hot springs along the lines of recent fracture may be taken as evidence of the conversion of the subterranean movement into heat.

What may have been the topography of the region before the first depression and isolation of the Great Basin is still unknown. Doubtless the ground had undergone extensive denudation as well as great subterranean disturbance. Considerable irregularities of surface would also necessarily be produced by the intermittent discharge of volcanic rocks. When this uneven floor sank below the level of the surrounding tracts so as to become a basin of inland drainage, a magnificent series of lakes was established. Of these the largest, to which the name of Lake Bonneville has been given, and of which the Great Salt Lake is the diminished representative, covered an area of not less than 19,750 square miles. Lake Lahontan was of hardly inferior dimensions, these two hydrographic basins occupying the whole breadth of the Great Basin in the latitude of the 41st parallel. No fewer than fifteen other smaller basins have been discovered, which though now either dry or partially covered with saline or alkaline waters, were well filled lakes at a former period.

It is some years since Mr. Gilbert, from a study of the deposits left by Lake Bonneville, announced his conclusion that they bear testimony to a remarkable oscillation of climate between humidity and aridity. Similar deductions have now been drawn from the deposits of Lake Lahontan. Previous to the appearance of this body of water the climate is believed to have been at least as dry as it is at present, when alluvial cones were pushed outward from the base of mountains into the area of the future lake. Then came a moist period, when the hollow of Lahontan was filled up with water to a depth of 500 feet above its present desiccated floor in the Carson Desert. At or about this height the water must have stood a long time, for it has deposited, along its rocky margin and round its islets, a thick mass of calcareous tufa. That the water, if not fresh, was at least not so saline as to be inimical to life, is shown by the abundant occurrence in it of fresh water gasteropods. An epoch of aridity ensuing, the lake fell to so low a level as to become intensely bitter and alkaline, depositing thickly along its margin crystals, six or eight inches long, of gaylussite (a hydrated carbonate of soda and lime). The soda of these crystals having been subsequently removed, the deposit is one of tufa, mainly composed of calcareous pseudomorphs after gaylussite. Next followed a period of increased precipitation, when the lake rose to within 200 feet of its highest level, and where the thickest and most abundant of the tufa deposits of the region was laid down to a depth of sometimes 20 or even 50 feet. This third incrustation of tufa was formed mainly along the rocky shores and islands; but curious mushroom-like protuberances of it likewise gathered upon stones lying on the floor of the lake. The water then rose to the highest level it ever reached, since which time the climate has again become arid. From the fact that the isolated lakes of the Lahontan Basin are not the saturated alkaline and saline solutions which they would certainly have been had they resulted from the evaporation of such a sheet of water as that in which the three tufa terraces were elaborated, it is inferred that the whole of the original lake was evaporated to dryness, and that its alkalies and salts, having been precipitated at the bottom, were covered over with a layer of mud so as to be partially protected from rapid solution. The existing lakes may thus be supposed to be the result of a subsequent diminution of the extreme aridity, but the time within which they have been in existence has not been long enough to enable them to become as bitter and saline as the original lake.

Such are some of the views which renewed exploration of this weird region has suggested to the able surveyors who have undertaken its investigation. Mr. Russell's report, lucid and interesting as it is, says *Nature*, must be regarded as merely a prelude to the fuller results which he and his colleagues are gathering for the good of science, and to the credit of the admirably organized and administered Geological Survey of the United States.



THE MILITARY TOURNAMENT AT THE AGRICULTURAL HALL—THE FIFTEENTH (KING'S OWN) HUSSARS GOING THROUGH THE NEW DRILL.

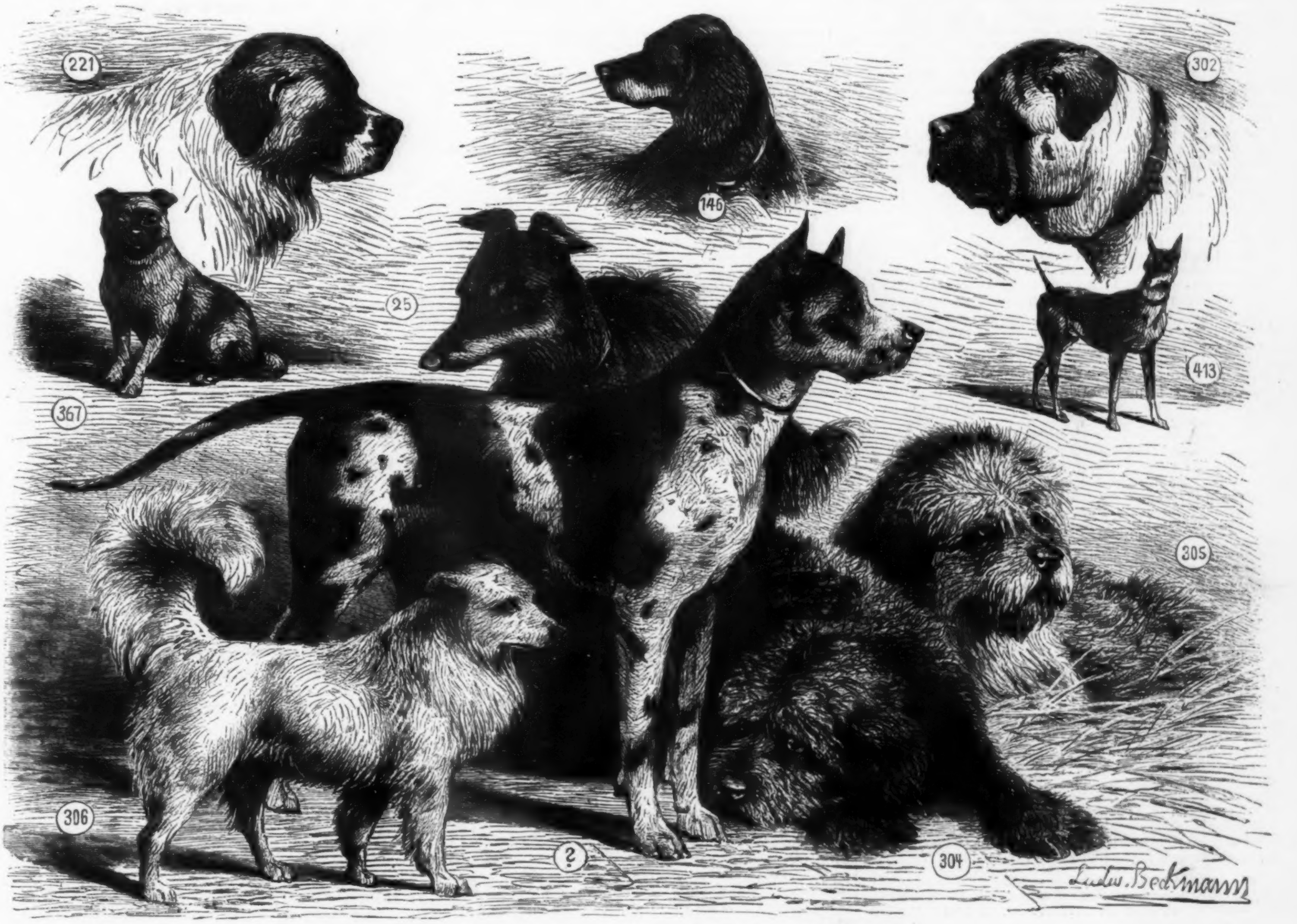
MILITARY TOURNAMENT AT THE AGRICULTURAL HALL.

THE fifth annual Military Tournament, which has recently been held at the Agricultural Hall, London, has been highly successful this year. There have been the always popular "musical ride" of the Life Guards, the wrestling, sword, lance, bayonet, tent-pegging, and artillery-driving contests, but in addition to the numerous trials of skill which the competitors are put through, there has been a novel field exercise display by the 15th Hussars. The troops put their horses through various evolutions, and at a given signal the men cause the horses to kneel, and then to lie down. The animals at once obeyed, and the riders, dismounting, knelt behind the bodies of their steeds, sometimes using them as cover, and fired their carbines at some imaginary enemy. The order being given to remount, each man simply placed himself astride of his horse, and was lifted up bodily as the charge rose to his feet. The docility of the horses, and the admirable training they had evidently received, coupled with the splendid form in which the men carried out the drill, won the hearty applause of the spectators.—*London Graphic.*

PRIZE DOGS OF THE VIENNA DOG SHOW.

IN the fall of 1883 the "Austrian Dog Fanciers' Club" was incorporated in Vienna, and the first dog show under the auspices of this club was opened March 23 and closed March 30. Hunting dogs were exhibited from the 23d to the 25th, and dogs of other kinds from the 28th to the 30th.

There were 186 hunting dogs in the show, of which the handsome Gordon setter, Black No. 146, in the annexed cut received the first prize. This animal is the property of the Austrian Crown Princess Stephanie.



PRIZE DOGS AT THE VIENNA DOG SHOW.

146. Black Gordon Setter; first prize. 25. "Jersey," Russian Greyhound. 304. "Medwit," Russian Shepherd's Dog; first prize. 305. "Cæsar," Russian Shepherd's Dog. (?) "Nero," Tigerhound not in competition. 302. "Boatswain," Mastiff; first prize. 221. "Rocher," St. Bernard Dog; first prize. 367. Pug; first prize. 413. "Muff," Dwarf Terrier. 306. "Attila," Hungarian Shepherd's Dog.

There were only three greyhounds exhibited; and of these the long-haired Russian hound "Jersey" received the prize. This dog belongs to the Crown Prince Rudolph of Austria. The animal is 28 in. high at the shoulder, of elegant and regular build, has beautiful hair, and is black with yellow spots over the eyes and has yellow legs. He is shown in the annexed cut as No. 25.

The exhibition of dogs not used for hunting purposes seemed to be the most interesting to the general public, and the 300 animals shown were worthy of the interest taken in them. From 25 to 28 Newfoundland dogs were exhibited, and several of them were conspicuous on account of their size and their beautiful hair, but the dog "Corno," which received the prize at Hanover, and the dog "Ouida" were the only typical dogs of this class. In the class of St. Bernard and Alpine dogs, "Rocher" received the first prize. He has long hair, white with reddish-yellow spots, and his head is regularly marked. He is shown as No. 221 in the cut.

About 50 German hounds were exhibited, and the handsomest of all, as well as the strongest and largest, was the tiger hound "Nero," marked "?" in the cut. Of the English mastiffs, "Boatswain," 302, was the only one worthy of notice, and he, principally on account of the typical shape of his head, is one of the finest animals of his class. The shepherds' dogs form a very interesting group in all dog shows, and among the large, long-haired Russian dogs "Medwit," a black animal of enormous size, is worthy of especial mention. He is closely followed by the whitish-gray or spotted dog "Caesar," No. 445. Large Hungarian shepherds' dogs were not represented, but a smaller kind, white with a handsome, long tail and short pointed ears was represented by "Attila," No. 306.

Some fancy dogs were exhibited, such as dwarf pinchers and Tay terriers. "Muff," No. 313, received the first prize for dwarf terriers.

The "Austrian Dog Fanciers' Club" has reason to be proud of its first exhibition, and it is to be hoped that many more successful exhibitions will follow.—*Illustrirte Zeitung.*

A DOG PLANS AND EXECUTES WITH REFERENCE TO THE FUTURE.

SIX weeks ago Prof. J. B. Thayer, of this place, returned from Ree Heights, Dakota, bringing with him one of a litter of eight pups raised by a slut of the setter breed. The story which he relates to me of this pup's mother is, it appears to me, worthy of record.

The good mother appears to have discharged her arduous duties as only a mother can, and arrived with her eight babes at the time when they should be weaned. At this juncture, judging from the events reported to have followed, she seems to have conceived the idea that too many dogs were occupying the same claim, and that a distribution was desirable.

Accordingly, she started one morning with three of her pups, and was observed by Miss Rosa Cheney, now of this place, running in the road toward their claim at a rate which made it impossible for the pups to keep pace with her. The dwelling where she lived, and another shanty on the adjoining corner of another claim, are situated one mile and three-quarters from the dog's home. The mother reached the claims in advance of her babes, but no sooner had they arrived than she hurried on at her best pace. Miss Cheney reports that "the puppies came up all out of breath, and apparently too tired to continue; but the smallest of the three followed on." Another claim was reached three-quarters of a mile beyond; and here Miss Cheney observed the mother stop until her panting babe came up, when she immediately set off again. A quarter of a mile beyond the last claim, the mother was observed to make a third halt as before, and then to pass on beyond the range of vision, toward Ree Heights, with the puppy still following her. Two days later the persistent mother, with her more persistent babe, was observed coming back, and Miss Cheney tells me that the little puppy appeared almost dead from fatigue.

Some days later the dog led off two more of her pups, and succeeded in leaving them both; but in the mean time the two puppies left the first day were returned. A pup was also left at Professor Thayer's claim, but was returned and exchanged for another. Both Professor Thayer and Miss Cheney assure me that other efforts of the same kind were made by this dog, but with what results they are unable to say.

After the puppies had been distributed, they were not forgotten; for the old dog used often to go and play with them. Professor Thayer mentions one instance of her coming and playing with the puppy left at his claim until it was very tired, when she lay down by the side of it; but after it had gone to sleep, she quietly walked to the opposite side of the house and then hurried away in the opposite direction from home for a distance of about forty rods, when she turned and went directly there, thus showing quite clearly that the thought of distributing her puppies was still uppermost in her mind.

What events may have awakened this desire on the part of the mother, or what reasons she had for her acts, we do not know; but in her own mind I have no doubt the case was urgent and the way clear, if not also just. It would appear not only that this dog must have thought her plan through, but that she must also have held it definitely in mind for several days while she executed it, thus indicating quite unequivocally, it seems to me, that one animal at least, ranked lower than man, possesses the power of looking into the future and of executing plans deliberately laid with reference thereto; "man is the only animal which has the power of looking into the future," to the contrary notwithstanding.—*F. H. King, in Science.*

River Falls, Pierce County, Wis.

THE GUISE CO-OPERATIVE EXPERIMENT.

ONE of the most extensive experiments in the participation of labor in profits is that which has been carried out for years at the Guise works, in the Aisne Department, France, formerly belonging to M. Godin, and still under his immediate charge. In 1859, M. Godin put up a large building called the "*familistère,*" for the accommodation of 300 families, adding a theater, school-house, etc. Twenty-one years later, he extended his plans, bringing forward the co-operative plan, which is interesting as a striking departure from similar experiments made elsewhere, and which, whatever its ultimate outcome, will always command the admiration of those interested in the relations between capital and labor.

The Societe du Familistère de Guise is composed of the founder, M. Godin, and of four classes of employes, "members," "associates," "participants," and "interested parties," whose rights and qualifications are defined as follows, in the by-laws, forming a part of a work published by Godin in 1880, entitled "Mutualité Sociále." The founder reserved the right to accept or reject any applications for admission to any one of the different classes, and of granting applications, even if certain qualifications are not complied with. He has the power to designate his successor during his lifetime or by testament. He has the power to propose modifications of the by-laws, even without the written consent, otherwise required, of two-thirds of the members. This power does not, however, descend to his successor, nor does the acquirement by inheritance of founder's shares entitle the owners to any of the founder's rights, or confer on the

heir or heirs the right to meddle with the affairs of the association. It carries with it simply the enjoyment of the proper share of the profits. "Members" must be at least twenty-five years of age, must have resided at least five years in the "familistère," and have worked during at least the same period in the shops of the company. They must be able to read and write, and must be owners of at least 500 francs' worth of the company shares. On the other hand, they have the first right to employment in times of scarcity of work, are entitled to a certain share in the profits, and are members of the assembly. "Associates" must be at least twenty-one years of age, be residents of the familistere, and have a record of three years' work with the company; while the "participants" must have served the company for a year, but need not be residents. They too share in the profits and take precedence in employment in case of short work. "Interested parties" are those who have acquired shares by purchase or inheritance. They draw interest to the extent of five per cent. on their capital, which is a first claim on profits, and share in the net returns. The interest on capital is paid in cash, the profits of labor are paid in certificates of savings of 50 francs each.

In case of the death of an employe, whose heirs are not members of the association, his certificates will be redeemed at one-half their face value, the other half being paid to the benefit funds. The "members" belong to the general assembly, which elects three members of the managing committee, of which the founder and general manager is president, and the six chiefs of departments are members. The general assembly receives the report of the general manager, and has a voice in matters touching the purchase or sale of plant, the raising of money, and all extraordinary expenditures.

The general manager has the sole right to sign in behalf of the association, and is its representative. The general assembly elects three persons from its number, who constitute the supervising committee, the duties of which are to examine books and to take part in the annual examination of the inventory. There are, besides, two other minor committees, the one having charge of the familistere, and the other deliberating on all industrial questions.

From the returns at the end of the fiscal year, 10 per cent. is first written off from the value of the material, and 5 per cent. from the value of the plant; than the grants to the benefit funds, the cost of education and instruction, and the interest on founder's and savings shares. The balance is the net profit, which is distributed as follows: Twenty-five per cent. goes to the reserve fund and for the purchase of shares, and fifty per cent. to capital and labor; that is, labor is represented by the total wages earned during the year, and capital by the interest on capital and savings shares, the dividends on capital being payable in cash, and the dividends on labor in savings shares. Out of the remainder, twelve per cent. is given to the general manager, nine per cent. to the members of the council, two per cent. to the supervising committee, and two per cent. is for distribution among those employes who have distinguished themselves by exceptional services. In the allotment to the workmen, the "members" are entitled to a share measured by twice the amount of their wages, the "associates" by one and one-half times their wages, and the "participants" by the exact amount of their wages.

Losses are borne by the reserve fund, and, when the latter is exhausted, by assessments. Roughly, therefore, after providing for a reserve fund, the profits are divided into three parts: one of them, the smallest, going to capital, in the form of cash; the second, the largest, going to labor in the shape of interest-bearing savings certificates; while a full third is devoted to compensation for services of administration.

The workings of the plan thus far have borne out the best hopes of its founder. In 1880, the association assumed the Guise and Laeken-les-Bruzelles works and the familistere buildings, put up in 1859, the patterns and patents, for 2,288,383·44 francs, the raw material and stock at 1,956,-012·17, and cash and funds to the value of 356,604·39 francs, a total of 4,600,000 francs, or more than a million of dollars, as the capital of the founder. The employes, numbering 1,022, did not put in anything but their skill as workmen and their good will; now, the men possess shares or certificates of savings representing a capital of 1,969,000 francs, and in from twelve to fifteen years they will be the proprietors of the entire establishment. It may be urged that this is certainly an extremely handsome showing for the men, but that it is not likely to be very encouraging to other employers to follow this example. Still Mr. Godin has had a very good thing of it. Practically he is selling his works to his men, instead of allowing it to pass by purchase into other hands and taking the risks from which he is now secured. The last fiscal year yielded him the following result, according to a statement in the *Genie Civil*:

Interest, 5 per cent. on the capital still in the concern, or 3,090,420 francs.	154,521	francs.
Salary as manager	15,000	"
Profit as a member	4,785	"
Profit on capital	24,646	"
Profit as manager	60,387	"
Total	259,339	"

Besides this, he has received a cash payment of 222,305 for retirement of that part of his capital, as provided for by the by-laws, whenever the reserved fund amounts to more than 10 per cent. of the capital of the association.

From the fact that the manager's profits are 12 per cent., we have computed that the total profit for the fiscal year must have been about 504,383 francs. The wages amounted to 1,888,000 francs, and the interest on capital to 230,000 francs; therefore the profits must have been distributed approximately as follows:

Reserve	125,806	francs.
Capital profits	27,328	"
Labor profits	224,284	"
Manager's share of profits	60,387	"
Managing committee	45,290	"
Supervising committee	10,644	"
Rewards	10,644	"
Total	504,383	"

The men therefore have acquired a share of the profits amounting substantially to nearly 12 per cent. of the total amount of their wages, which goes into capital account and draws interest in succeeding years. Besides this, the laborer has an interest in three societies, one an insurance fund for the necessities of life, another an insurance against infirmity or old age, and the third against sickness.

The first is mainly provided for by the payment of a sum equal to two per cent. of the wages by the association, its object being to contribute to the necessities of members, even when capable of working, when their income is insufficient. The sums vary from 1 to 2·50 francs a day for men, and from 0·75 to 1·50 francs a day for women, according to length of service. The third fund is maintained by the employes by the payment of 1·5 per cent.

The Guise experiment is therefore based on an elaborate system, of which we have simply given the rough outlines, the details being carefully worked out. Its main principles are the dwelling together of the workmen in one large building; a progressive grading of participation in the profits of the work, represented by the acquirement of a growing interest in it; the comparatively small share of capital in the profits; and the large amount paid to management. It is, of course, impossible to judge how much of the success of this co-operative enterprise is due to the personal influence and efforts of its founder, M. Godin; nor has it, thus far, we believe, borne the crucial test of all such attempts, the severe strain of a long-continued period of dullness, shortage of work, and shrinkage of profits.

Thus far, from all the accounts that have reached us, it is eminently a success, and it differs in so many important points from any former co-operative plans that it is not idle to believe that it has elements of vitality that they did not possess. Many features of it, of course, would be entirely out of place in our own country; but they are well fitted to meet the peculiarities of the relations between employer and employed abroad.—*The Engineering and Mining Journal.*

THE ECONOMIC USES OF THE MEZQUIT.

In an interesting article in the *American Naturalist* upon the mezquit—a tree which forms the most notable feature of our southwestern sylva—Dr. V. Havard, U. S. A., gives the following as its economic uses:

The foliage of the mezquit is practically useless. If at times goats or mules are seen to browse it, one may be sure there is no other food within reach. I have been told that, on the Lower Rio Grande, cows sometimes eat the young leaves in the early spring, and that their milk, in consequence, becomes bitter and unfit to use.

The trunk is ordinarily too short, and often too crooked and knotty to make it serviceable as timber. Mezquit posts, much used in fencing, are said to be indestructible, whether under or above ground.

I believe this plant is capable of making excellent hedges. Seedlings, as mentioned before, are easily raised, and if transplanted in prepared ground during the rainy season, they should, in three or four years, develop into vigorous shoots, which, by proper pruning and trimming, will form impenetrable hedges.

The wood is very hard, heavy, fine-grained, and takes a beautiful polish. Longitudinal sections are prettily marked with wavy, sinuous veins; the very eccentric rings, although very close, are distinct; the serried medullary rays are hardly visible to the naked eye. The heart-wood is richly colored, its several zones varying from yellowish-red to purple, and contrasts sharply with the pale yellow of the superficial layers. These qualities render mezquit wood valuable for cabinet-work. Unfortunately it too often happens that the zones of the heart-wood are fissured, decayed, or detached from each other, so that it is difficult to get flawless boards.

In San Antonio and Brownsville, Texas, pavement blocks of mezquit are used on several streets, and said to answer the purpose excellently well.

As fuel, the wood, from both root and stem, is unsurpassed. It is the most commonly used from San Antonio, Texas, to San Diego, California, and often the only kind obtainable. According to Dr. Loew, the charcoal made from this wood is of the best quality for metallurgical and smelting purposes.

During the summer months, from May to September, there exudes from the bark of the mezquit a gum which concretes in tears of variable size, and of a light amber color. It has the taste of gum arabic, makes excellent mucilage, and dissolves readily in three parts of water, the solution having a slight acid reaction. Chemically, it is distinguished from gum arabic in not being affected by subacetate of lead, which in a solution of the latter throws down a thick white precipitate.

This gum is mostly found in old, decrepit trees, with thick, cracked bark, and accumulates in knot-holes and around fractures. More rarely is it seen on young, vigorous, and smooth-barked trees. The yield is increased by practicing incisions on the trunk. In these the gum which slowly forms above, under the cambium layers, demonstrates its derivation from the descending sap. It often happens that the exudation fails to concrete, and runs upon the bark in large, black, tarry streaks and patches.

The quantity of gum naturally produced during the season by a large tree is small, probably not exceeding a third of a pound. It is doubtful whether the yield could be increased to a pound by incisions. Therefore this gum, although of prime quality, can hardly ever become an important article of trade.

The fruit of the mezquit contains nutritive principles which make it a valuable article of food. Most herbivorous animals are fond of it, and thrive on it. In the field it is a welcome though imperfect substitute for grain. Horses and mules soon learn to know the tree or bush, always abundantly fructiferous, and as soon as let loose go in search of the fallen pods lying in the grass under the thorny branches. While green, and until thoroughly ripened, the "beans" are bitter and worthless as food. At full maturity they fall to the ground, when they should be at once collected before wetted by rain, and stored in a dry place. Under these conditions they keep well until the next crop. When left on the ground, they soon deteriorate and decay. They have a particular enemy in a small coleopterous insect which lays its eggs in the seeds, so that in picking up an old pod we shall usually find each joint bored with a hole leading to the corresponding seed.

If we take the dry pod, thoroughly triturate it in a mortar with water, and afterward strain, we get an aqueous extract containing all of its nutritive elements. The residue, nearly one-half (forty-seven per cent.) of the whole pod, consists of shreds of the epicarp, the broken endocarp, and the seeds; it is indigestible, and always voided with the fæces. The aqueous extract, containing fifty-three per cent. of the pod, consists of vegetable albumen, gum, and grape-sugar, with traces of fat and salts. Its pleasant sweetness to the taste at once reveals the presence of sugar; but, owing to some interfering principle, the usual reagents fail to show even a trace of it. It is only after extraction with alcohol, evaporation, and solution in water that Fehling's test can be successfully applied. A careful analysis yielded twenty-six per cent. of glucose. Dr. Loew (Rothrock, Botany W. of the 100th meridian) found thirty per cent.

Thus it is seen that mezquit "beans" differ widely from corn or oats in composition, and therefore cannot produce the same effect on animals. Only about one-half its weight being assimilable, it is a much more bulky food. It is rich in sugar and nitrogen, but deficient in starch, fat, and salts. Before the advent of railroads, when grain was scarce in San Antonio, mezquit pods were regularly brought to market and sold for a dollar a bushel.

They constitute a favorite food of Mexicans and Indians. The ripe pod is ground on the "matate," the seeds picked out, and the coarse flour thus obtained is cooked into cakes, or, after seasoning, wrapped in corn husks like "tomales." Mezquit "atole" is made by throwing the pods into boiling water; when cooked, they are put in fresh water and pounded into a pulp, which is strained; the liquor, containing in suspension and solution all the nutriment of the fruit, is drank *ad libitum*, and is a very pleasant beverage. Or, again, the pods may be triturated first and the flour boiled afterward.

The infusion of this flour can easily be made to undergo alcoholic fermentation, whereby a weak beer is obtained, formerly much used by Comanche and Apache Indians.

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